GRISWOLD'S

RAILROAD ENGINEERS'

POCKET COMPANION

For the Field.

COMPRISING

RULES FOR CALCULATING DEFLEXION DISTANCES AND ANGLES,
TANGENTIAL DISTANCES AND ANGLES, AND ALL
NECESSARY TABLES FOR ENGINEERS;

ALSO,

THE ART OF LEVELING FROM PRELIMINARY SURVEY TO THE
CONSTRUCTION OF RAILROADS, INTENDED EXPRESSLY
FOR THE YOUNG ENGINEER

TOGETHER

WITH NUMEROUS VALUABLE RULES AND EXAMPLES.

BY W. GRISWOLD.

PREFACE.

In offering this book to the patronage of the Assistant Engineer, I would wish to remark, that the book is composed of notes that I have long been collecting.

Every Engineer has his private book of Rules, that should he want for memory in the field, he has only to refer to his book.

This book I have intended for the same object.

For the benefit of the young Engineer, I have inserted the art of leveling, running levels (as it is termed) in plain language, from preliminary surveys to the construction of a railroad; the manner of taking cross sections of the road bed, and setting slope stakes, with its rules. Every feature of the book has a tendency to attract the attention of both the Assistant and the young Engineer.

Tables that would be more used by the Assistant Engineer, are inserted, which can be relied upon as correct, as I have taken them from reliable authors.

In the art of leveling, I have made no allowance for the Earth's curvature, as in practice upon railroads no allowance is ever made.

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RAILROAD ENGINEER'S

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FOR THE FIELD.

EXPLANATION OF LETTERS AND TERMS.

P. C. Point of curve.   *E. C.* End of curve.
T. P. Tangent point.
1 Station is equal to 100 feet.
A Plus Station is any number of feet less than 100.
B. S. Back sight.   *F. S.* Fore sight.
Int. S. Intermediate sight.   *H. Ins.* Height of instrument.

CURVATURE.

To find the radius of curves, from the deflexion angles, from chord to chord.   (Chord 100 ft.)

RULE 1.

As angle of deflexion
Is to the length of the chord,
So is 57.3 to radius.

To find radius of curves, from the deflexion distance, from chord to chord.   (Chord 100 ft.)

RULE 2.

The square of the chord, divided by the deflexion distance.

EXAMPLE.— Deflexion distance $= 3.\frac{49}{100}$ ft.;

Square of chord 10,000;

3.49)10,000(2865, radius.

To find the radius of a curve, from the deflexion angle, on chord of 100 ft.

RULE 3.

Divide the radius of a one degree curve (5,730) by the degrees of deflexion of 100 ft.

To find radius of a segment of a circle.

RULE 4.

Square of half the chord, added to the square of versed sine, = square of chord of half the arc; and square of chord of half the arc, divided by versed sine, = diameter, $\frac{1}{2}$ = radius.

When the angle at vertex is given, and radius, to find the tangent point.

RULE 5.

Multiply nat. tangent of half the whole angle in the curve, by radius of curve; will equal distance from vertex to tangent point.

When the distance from vertex to tangent point, and angle given, to find radius.

RULE 6.

Subtract the angle $a\ b\ c$, (Fig. 1) which is half the angle $a\ b\ d$, from 90°; the remainder will be the angle $b\ c\ a$.

Then say: As nat. sine of $b\ c\ a$ is to nat. sine of $a\ b\ c$, so is $a\ b$ or $b\ d$ to the radius.

Having given the angle *a b d*, (Fig. 1) it is required to find the point *a* or *d*, at which to commence a curve, of a given radius.

RULE 7.

Subtract half the angle *a b d* from 90°, the remainder will be the angle *b c a* or *b c d*; then take the natural tangent of *b c a* or *b c d*, and multiply it by the given radius; the product will be *b a* or *b d*.

Having the given radius (Fig. 1) *a c*, or deflexion angle for 100 ft., of a curve, and the angle *a b d*, it is required to find the number of chords of 100 ft. that will constitute the curve.

RULE 8.

Subtract the angle *a b d* from 180°, and divide the remainder by the angle of deflexion in 100 ft.

Having the angle at vertex (Fig. 1) *e b d*, (which is the number of degrees in the curve,) and deflexion angle for 100 ft., to find the number of chords in that curve.

RULE 9.

Divide the number of degrees at vertex by deflexion angle.

With the distance *a b* or *b d*, and radius *a c* given, to find the distance from *f* to *b*, (Fig. 1.)

RULE 10.

The square of the distance from vertex to *P. C.* divided by twice the radius.

Fig. 1
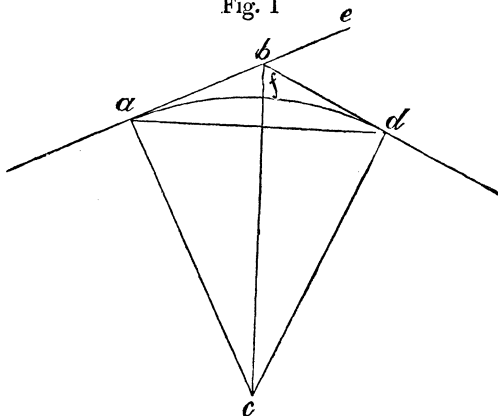
EXAMPLE.— Suppose the distance from a to $b =$ 511 ft., and radius = 1,910 ft.,

Then $511^2 = 261,121 \div 2 \times 1,910 = 68.2$, Answer.

NOTE.— The square of any distance, divided by twice radius, will equal the distance from tangent to curve, very nearly.

When the distance $a\,b$ or $b\,d$ is given, and distance $f\,b$, (Fig. 1) to find radius.

RULE 11.

Divide the square of the distance $a\,b$ or $b\,d$ by the distance $f\,b$, equals twice the length of radius, $\frac{1}{2}$ = radius.

EXAMPLE.— Suppose the distance $f\,b$ equals 68.2, and $a\,b$ or $b\,d$ equal 511.

STATEMENT.— $511^2 = 261{,}121 \div 68.2 = 3{,}820 \div 2 = 1{,}910$, radius.

To find the radius corresponding to any given angle of deflexion, and to equal chords of any given length.

RULE 12.

Subtract the angle of deflexion from 180°; then say: as nat. sine of angle of deflexion, is to nat. sine of half the remainder, so is the given chord to the radius required.

EXAMPLE.— Let the angle of deflexion be 2°, and the chord 100 ft., required the radius.

Then $2° - 180° = 178° \div 2 = 89°$.

<div style="text-align:center">N. S. 2°.   N. Sine 89°. Chord.</div>

STATEMENT.— $0.0349 : .999848 :: 100 : 2865$, radius.

To find the circumference of a circle, when the diameter is given, or the diameter, when the circumference is given.

RULE 13.

Multiply the diameter by 3.1416, equals circumference; or, divide the circumference by 3.1416, equals diameter.

2d. As 7 is to 22,
     So is the diameter to the circumference.
     Or, as 22 is to 7,
     So is the circumference to the diameter.

To find the length of an arc or circle, containing any number of degrees.

RULE 14.

Multiply the number of degrees in the given arc,

by 0.0087266, and the product by the diameter **of** the circle.

Note.— The circumference of a circle, whose diameter is 1, is 3.1416; it follows, that if 3.1416 be divided by 360°, the quotient will be the length of an arc of 1 degree, ⇒ 0.0087266.

Remark.—When the arc contains degrees and minutes, reduce the minutes to a decimal of a degree.

To find the length of any arc of a circle.

RULE 15.

Subtract the chord of the whole arc from 8 times the chord of half the arc, and $\frac{2}{3}$ of the remainder is the length of the arc, nearly.

When the chord of **the arc, and** the chord of **half** the arc, are given.

RULE 16.

From the square of the chord of half the arc, subtract the square of half the chord of the entire arc; will equal the square of the versed sine; extract the square root; will equal versed sine — the versed sine and the chord given — the square of $\frac{1}{2}$ the length of the chord, added to the square of the versed sine, and square root of the remainder, will equal chord of $\frac{1}{2}$ the arc; multiply the remainder by 8, subtract the chord of the whole arc, and divide by 3, equals length of arc.

To find the circumference of an ellipses.

RULE 17.

Half the sum of the two diameters, multiplied **by** 3.1416; the product will equal circumference.

TABLE OF RADII — CHORDS 100 FT.

Angle of Deflexion.	Radius in Feet.	Angle of Deflexion.	Radius in Feet.	Angle of Deflexion.	Radius in Feet.	Angle of Deflexion.	Radius in Feet.
° ′		° ′		° ′		° ′	
0 15	22920	8 15	695·1	16 15	353·8	24 15	238·0
30	11460	30	674·6	30	348·4	30	235 6
45	7640	45	655·5	45	343·3	45	233·3
1	5730	9	637·3	17	338·3	25	231·0
15	4584	15	620·2	15	333·7	15	228·7
30	3820	30	603·8	30	328·7	30	226·5
45	3274	45	588·4	45	324·8	45	224·3
2	2865	10	573·7	18	319·6	26	222·3
15	2547	15	559·7	15	315·2	15	220·6
30	2292	30	546·4	30	311·0	30	218·0
45	2084·0	45	533·8	45	306·9	45	216·0
3	1910	11	521·7	19	302 9	27	214·2
15	1763	15	510·1	15	299·4	15	212·2
30	1637	30	499·1	30	295 3	30	210 3
45	1528	45	488·5	45	291·5	45	208·5
4	1433	12	478·3	20	287·9	28	206·7
15	1348	15	468·7	15	284·4	29	199·7
30	1274	30	459·3	30	280.9	30	193·2
45	1207	45	450·3	45	277·6	31	187·1
5	1146	13	441·7	21	274·4	32	181·4
15	1092	15	433·4	15	271·1	33	176·0
30	1042	30	425·5	30	268·0	34	171·0
45	996·8	45	417·7	45	265·0	35	166·3
6	955·4	14	410·3	22	262·0	36	161·8
15	917·0	15	403·1	15	260·0	37	157·6
30	882·0	30	396·2	30	257·4	38	153 6
45	849·3	45	389·6	45	254·6	39	149·8
7	819·0	15	383·1	23	250·8	40	146·2
15	790·8	15	376·9	15	248·1	45	136·5
30	764·5	30	370·8	30	245·5		
45	739 9	45	365·0	45	242·9		
8	716·8	16	359·3	24	240·5		

2

To find the radius corresponding to any given angle of deflexion, and to equal chords of any given length.

RULE 18.

Subtract the angle of deflexion from 180°; then say: as nat. sine of angle of deflexion is to nat. sine of half the remainder, so is the given chord to the radius required.

Fig. 2.
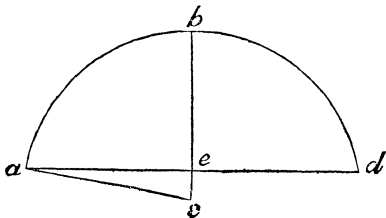
With the chord and versed sine given, to find the radius.

RULE 19.

The square of half the chord divided by versed sine; to which add the versed sine, and divide by 2.

EXAMPLE.— Suppose we have an arc (Fig. 2) with a chord $a\ d$ of five feet, and versed sine $e\ b$ two feet, what is the radius $a\ c$?

STATEMENT.— $5 \div 2 = 2 \cdot 5^2 = 6 \cdot 25 \div 2 = 3 \cdot 125 +$ $2 = 5 \cdot 125 \div 2 = 2 \cdot 5625$, radius $a\ c$.

We have two tangents with their courses given. We wish to unite those tangents, with a curve of a given radius.

Suppose we have a tangent whose course is $N.$ 30° $E.$, (Fig. 3) which we wish to unite with a 3° curve to a tangent whose course is $S.$ 50° $E.$ We here find we have the difference of courses to be 100°. According to Rule 8, page 7, and Rule 20, page 14, we have $3,333\frac{33}{100}$ ft. to run. We start on the first given tangent, and run $3,333\frac{33}{100}$ ft. If our curve does not form a tangent of the line $g\,e$, but touches the point c, we measure in a line the same course of the first tangent, $N.$ 30° $E.$, to its intersection, which distance you measure backward or forward for $P.\ C.$

Fig. 3.
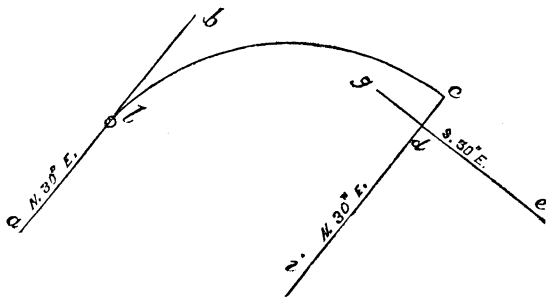
EXAMPLE.—We have the tangent $a\,b$, $N.$ 30° $E.$, and tangent $e\,g$, $S.$ 50° $E.$; we wish to join those two tangents with a 3° curve.

STATEMENT.—$T.\ N.$ 30° $E.$ and $T.\ S.$ 50° $E. =$ 100°, angle of deflexion, which makes 100° in the curve; consequently, the number of feet in the curve

(chords 100 ft.) $= 100° \div 3 = 33$ stations and $33\frac{33}{100}$ ft. $= 3,333\frac{33}{100}$ ft. We start from the tangent a b, at the point l, and run $3,333\frac{33}{100}$ ft., turning off for a $3°$ curve, and find, when arriving at our tangent, we are 250 ft. from the line, as d c; we then return and measure the same distance on the tangent a b from $l.$ to $P.$ $C.$

With the angle at vertex given, and degree of curvature, to find how many feet constitutes the curve.

RULE 20.

Divide the number of degrees at vertex, by degree of curvature.

EXAMPLE.—We have the angle at vertex $= 100°$, and degree of curvature $= 3°$.

STATEMENT.— $100° \div 3° = 33$ stations and $33\frac{33}{100}$ ft. $= 3,333\frac{33}{100}$ ft.

If there is any number of feet less than 100 ft., in your curve, to find how many degrees and minutes to turn off.

RULE 21.

Say: as 100 ft. is to the number of feet you wish to run, so is the number of degrees and minutes to the number of degrees and minutes you wish to find.

EXAMPLE.— Suppose you turn off in every 100 ft., $1° \; 30'$, how much will it be necessary to turn off in 33 ft.?

STATEMENT.— $100 : 33 :: 1° \; 30' : 30'$, Answer.

Suppose you have a less number of degrees and minutes, than you turn off in 100 ft., to find the number of feet necessary to measure.

RULE 22.

As the whole number of degrees and minutes is to the number of degrees and minutes you wish to turn off, so is the chord, 100 ft., to the number of feet required.

EXAMPLE.—We turn off in 100 ft. 1° 30′, we wish to find the number of feet to measure for 30′.

STATEMENT.—1° 30′ : 30′ :: 100 : 33, Answer.

Fig. 4.
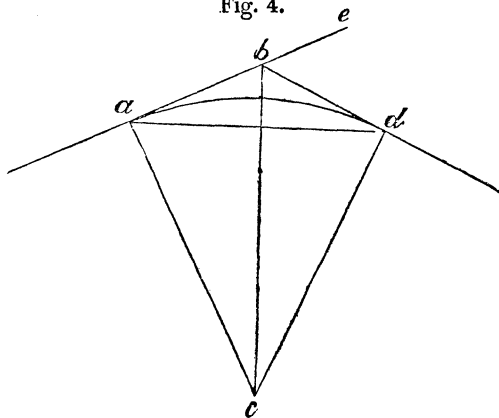
With the angle *a b d*, (Fig. 4) and distance *a b* given, to find radius *a c*.

RULE 23.

Half the angle *a b d* taken from 90° = angle *a c b*.

Then say: as nat. sine of *a c b* is to nat. sine of *a b c*, so is the given side *a b* or *b d* to the radius *a c*.

NOTE.—This rule is often used in compounding curves, where the curve you have run does not fit the tangent, by measuring from a given point, on a tangent, to curve already run, to the tangent you wish to connect, as *b l* (Fig. 5) and measuring the angle *c d l*, and proceed according to rule 23.

Thus in Fig. 5, we run our curve to *n*, and find that it does not come in tangentially to the tangent *b l*, therefore to save loss of time, in long curves, we retrace our steps to the point *c*, and measure tangentially to curve *a c*, as *c d* to the tangent *b l*, and measure the angle *c d l*, and form a new radius, as *c g* or *e g*.

Fig. 5.
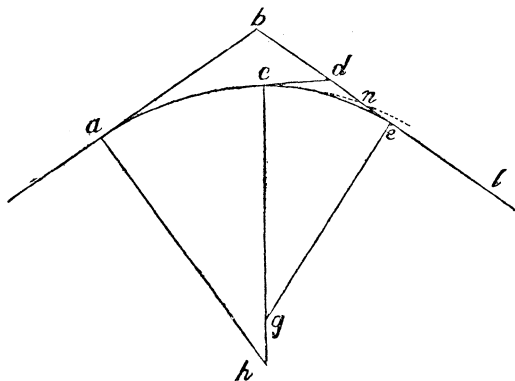
We oftentimes have two different angles in a line, and in such close proximity that it is required to put in reversed curves (Fig. 6) that will connect with the greatest possible radius; we then wish to find

the greatest radius *a h* and *e g* that will connect the tangents with a reversed curve.

Fig. 6.
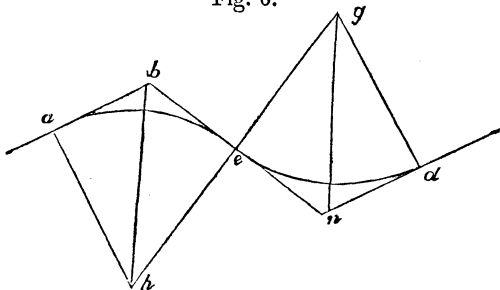
RULE 24.

Half the angle *a b e* taken from 90° leaves the angle *b h e* or *a h b*, and half the angle *b n d* taken from 90° leaves the angle *e g n*. From the table of nat. tangent take the nat. tangent of *b h e* or *a h b* and nat. tangent of the angle *e g n* and add them together.

Then say: as the sum of these two nat. tangents is to the nat. tangent of *b h e*, so is the distance *b n* to *b e*.

Again, in the triangle *b h e*, as the nat. sine of the angle *b h e*, opposite the given side *b e* just found, is to the nat. sine of the angle *h b e*, opposite the required side *h e*, so is *b e* to *h e*, the radius required.

EXAMPLE.— Let the angle *a b n* be 71° 40′, the angle *b n d* 129° 15′, and the distance *b n* be 950 ft., what is the length of the radius *h e* or *e g?*

STATEMENT 1st.— 71° 40′ ÷ 2 = 35° 50′ — 90 = 54° 10′.

129° 15′ ÷ 2 = 64° 37$\frac{1}{2}$′ — 90 = 25° 22$\frac{1}{2}$′.

Nat. tangent of 54° 10′ = 1·3848.

Nat. tangent of 25° 22$\frac{1}{2}$′ = 0·4743 + 1·3848 = 1·8591.

Sum. N. tang. 54° 10′ *b n*   *b e*

Then as 1·8591 : 1·3848 :: 950ft. : 707·63 ft.

Again, 950 — 707·63 = 242·37 ft. = *e n*.

Sine *b h e*. N. sine *h b e*.

STATEMENT 2d.— 0·8107 :·5854 :: 707·63 : 510·97, radius required.

Hence, we have the distance *h e* and *e g* = 510·97 ft., and distance *b e* 707·63 ft., and distance *e n* 342·37 ft., and degree of curvature equal to 11° 16′ for chords of 100 f.

The radius of a curve is always at right angles with its tangent.

When running curves with a compass, or transit instrument, always turn off on the vernia, one-half the number of degrees as contains degrees of curvature; because when running with an instrument, you are running tangential angles instead of deflexion angles, and the tangential angle equals one-half the deflexion angle.

ORDINATES.

To find ordinates on chords of 100 ft.

RULE 1.

The product of the segment, divided by twice the radius.

EXAMPLE.— Suppose the radius = 2·865 ft.; what would be the ordinate for 25 ft.? (Chords 100 ft.)

$25 \times 75 \div 5,730 = 0·327$.

Rule for getting the ordinate for 50 ft. and 25 ft. approximately.

RULE 2.

For an ordinate of 50 ft., divide the deflexion distance for 100 ft. by 8. For 25 ft. three-fourths of the ordinate for 50 ft.

EXAMPLE. — Suppose the deflexion = 3°, which deflexion distance = 5·235 ÷ 8 = 0·654, ordinate for 50 ft., and three-fourths of 0·654 = 0·491, ordinate for 25 ft.

To find the middle ordinate to any given radius, and to any given chord.

RULE 3.

From the square of the radius, subtract the square of half the chord, and take the square root of the remainder from the radius = middle ordinate.

EXAMPLE.—What is the length of the middle ordinate $d\ e$, (Fig. 1) the radius $a\ c$ being 2·5625, and chord $a\ b$ 5 ft.

STATEMENT.—$2·5625^2 - 2·5^2 = \sqrt{·316406} = ·5625$ — $2·5625 = 2$ ft., middle ordinate.

TABLE OF ORDINATES — CHORDS 100 FT.

Angle of Deflexion	Length of Ordinates in Feet.									
	50	45	40	35	30	25	20	15	10	5
0° 5′	·018	·018	·017	·016	·015	·014	·012	·009	·006	·003
10	·036	·036	·035	·033	·031	·027	·023	·019	·013	·007
15	·054	·054	·052	·049	·046	·041	·035	·028	·019	·010
20	·073	·072	·070	·066	·061	·055	·047	·037	·026	·014
25	·091	·090	·087	·082	·076	·068	·058	·046	·032	·017
30	·109	·108	·105	·099	·092	·082	·070	·055	·039	·020
35	·127	·126	·123	·116	·108	·096	·082	·065	·045	·024
40	·145	·144	·140	·133	·123	·110	·093	·074	·052	·027
45	·163	·161	·157	·149	·137	·123	·105	·083	·058	·031
50	·182	·180	·175	·166	·153	·138	·117	·092	·065	·034
55	·200	·198	·192	·182	·168	·151	·128	·102	·071	·038
1	·218	·216	·209	·198	·183	·164	·140	·111	·078	·041
5	·236	·234	·226	·215	·198	·178	·152	·120	·085	·044
10	·254	·252	·244	·231	·214	·191	·163	·130	·091	·048
15	·273	·270	·261	·248	·229	·205	·175	·139	·098	·051
20	·291	·288	·279	·264	·244	·218	·187	·148	·104	·055
25	·309	·306	·296	·281	·259	·232	·198	·157	·111	·058
30	·327	·324	·314	·297	·275	·246	·210	·167	·117	·062
35	·345	·342	·331	·314	·290	·259	·221	·176	·124	·065
40	·364	·360	·349	·330	·305	·273	·233	·185	·130	·069
45	·382	·378	·366	·347	·321	·287	·245	·195	·137	·072
50	·400	·396	·384	·364	·336	·300	·256	·204	·144	·076
55	·418	·414	·401	·380	·351	·314	·268	·213	·150	·079
2	·436	·432	·419	·397	·366	·327	·280	·222	·157	·083
5	·454	·450	·436	·413	·382	·341	·291	·232	·163	·086
10	·473	·468	·454	·430	·397	·355	·303	·241	·170	·089
15	·491	·486	·471	·446	·412	·368	·315	·250	·176	·093
20	·509	·504	·489	·463	·428	·382	·326	·260	·183	·096
25	·527	·522	·506	·480	·443	·396	·338	·269	·190	·100
30	·545	·540	·524	·496	·458	·409	·350	·278	·196	·103
35	·564	·558	·541	·513	·474	·423	·361	·288	·203	·107
40	·582	·576	·559	·529	·489	·436	·373	·297	·209	·110
45	·600	·594	·576	·546	·504	·450	·384	·306	·216	·114
50	·618	·612	·594	·562	·519	·464	·396	·315	·222	·117
55	·636	·630	·611	·579	·535	·477	·408	·325	·229	121
3	·654	·648	·629	·595	·550	·491	·419	·334	·235	·124
5	·673	·666	·646	·612	·565	·504	·431	·343	·242	·128
10	·691	·684	·664	·629	·581	·518	·443	·353	·249	·131
15	·709	·702	·681	·645	·596	·532	·454	·362	·255	·134
20	·727	·720	·699	·662	·611	·545	466	·371	262	·138
25	·745	·738	·716	·678	·627	·559	·478	·380	·268	·141
30	·764	·756	·734	·695	·642	·573	489	·390	·275	·145
35	·782	·774	·751	·711	·657	·586	·501	·399	·281	·148
40	·800	·792	·769	·728	·673	·600	·512	·408	·288	·152
45	·818	·810	·786	·744	·688	·613	·524	·418	·294	·155
50	·836	·828	·804	·761	·703	·627	·536	·427	·301	·159
55	·854	·846	·821	·778	·718	·641	·547	·436	·308	·162
4	·873	·864	·839	·794	·734	·654	·559	·445	·314	·166

TABLE OF ORDINATES — CHORDS 100 FT.

Angle of Deflexion	Length of Ordinates in Feet.									
° ′	50	45	40	35	30	25	20	15	10	5
4 15	·927	·918	·891	·844	·780	·695	·594	473	334	·176
30	·981	·972	·944	·893	·825	·736	·629	·501	·354	·186
45	1·036	1·026	·996	·943	·871	·777	·664	·529	·373	·196
5	1·091	1·080	1·048	·993	·917	·818	·699	·557	·393	·207
15	1·146	1·134	1·100	1·042	·963	·859	·734	·585	·413	·217
30	1·200	1·188	1·153	1·092	1·009	·900	·769	·613	·432	·228
45	1·255	1·242	1·205	1·141	1·055	·941	·804	·640	·452	·238
6	1·309	1·296	1·258	1·191	1·100	·982	·839	·668	·472	·249
30	1·419	1·404	1·362	1·290	1·192	1·064	·909	·724	·511	·269
45	1·473	1·458	1·415	1·339	1·238	1·105	·944	·752	·531	·290
7	1·528	1·512	1·467	1·389	1·284	1·146	·979	·779	·551	·290
30	1·637	1·620	1·572	1·488	1·375	1·228	1·048	·835	·590	·311
8	1·746	1·728	1·677	1·587	1·467	1·310	1·118	·891	·629	·332
30	1·855	1·836	1·782	1·687	1·559	1·392	1·188	·946	·669	·353
9	1·965	1·944	1·886	1·787	1·651	1·474	1·258	1·002	·708	·373
30	2·074	2·052	1·991	1·887	1·742	1 556	1·328	1·057	·748	·394
10	2·183	2·161	2·096	1·987	1·834	1 637	1·398	1·114	·787	·415
30	2·292	2·269	2·201	2·087	1·926	1·719	1·468	1·170	·827	·436
11	2·401	2 377	2·306	2·186	2·018	1·802	1·538	1·226	·866	·457
30	2·511	2·486	2·411	2·236	2·110	1·884	1·609	1·282	906	·478
12	2·620	2·594	2·516	2·386	2·203	1·967	1·680	1 339	·946	·499
13	2·839	2·811	2·726	2·585	2·387	2·132	1·820	1·451	1·025	·541
14	3·058	3·028	2·937	2·785	2·571	2·297	1·961	1·564	1·105	·583
15	3·277	3·245	3·147	2·984	2·756	2·462	2·102	1·676	1·184	·625
16	3·496	3·462	3·358	3 184	2·941	2·627	2·243	1·789	1·264	·667
17	3·716	3·680	3·569	3·384	3·125	2 792	2·384	1·902	1·344	·709
18	3·935	3·897	3·779	3·584	3·310	2·958	2·525	2·014	1·424	·751
19	4·155	4·115	3·990	3·784	3·495	3·123	2·666	2·127	1·504	·793
20	4·375	4·332	4·201	3·984	3 680	3·288	2·808	2·240	1·583	·836
21	4·595	4·549	4·412	4·184	3·864	3·454	2·950	2·353	1·663	·879
22	4·815	4·768	4·624	4·386	4 050	3·620	3 093	2·467	1·744	·922
23	5·035	4·986	4·836	4·587	4·237	3·786	3 236	2·581	1·824	·965
24	5·255	5 204	5·048	4·789	4·423	3·952	3·379	2·695	1·905	1·008
25	5 476	5·422	5·260	4·989	4·609	4 119	3·522	2·809	1 986	1 051
26	5·697	5·642	5·473	5·192	4·798	4·286	3·665	2·924	2·068	1·094
27	5 918	5·860	5·685	5·393	4·984	4·454	3·808	3·039	2·150	1·137
28	6·139	6·079	5·898	5·595	5·171	4·622	3·952	3·154	2·232	1·181
29	6·361	6 298	6·110	5·796	5·357	4·790	4·095	3·269	2·314	1·224
30	6·582	6·517	6·323	5·999	5·544	4·958	4·239	3·385	2·396	1·268
31	6·804	6·737	6 537	6·202	5·733	5 127	4·384	3·502	2·481	1·312
32	7·027	6·957	6·751	6·406	5·922	5·297	4·530	3·619	2·565	1 356
33	7·249	7·178	6·965	6·609	6·111	5·467	4·676	3·737	2·649	1·401
34	7·472	7·398	7·179	6·813	6 300	5·637	4·822	3·854	2·733	1·445
35	7·694	7·619	7·393	7·017	6·489	5 807	4·968	3·972	2·817	1·490
36	7·918	7 841	7·609	7·222	6·679	5·978	5 115	4 090	2·901	1·535
37	8·143	8 063	7·825	7·427	6·870	6·149	5·262	4·209	2·985	1·581
38	8·367	8·286	8·041	7·633	7·060	6·320	5·410	4·327	3·069	1·626

RULE 4.

Subtract the tabular cosine of the tangential angles from 1, and multiply the remainder by the radius. (Chords 100 ft.)

EXAMPLE.— Radius 819 ft., angle of deflexion would be 7° to chord of 100 ft; what will be the length of the middle ordinate?

STATEMENT.— Here tabular cosine of the tangential angle $3\frac{1}{2}° = \cdot998135$, which, subtracted from $1 = \cdot001865$, which, multiplied by radius, 819 ft., $=$ ordinate, 1·528.

Fig. 1.
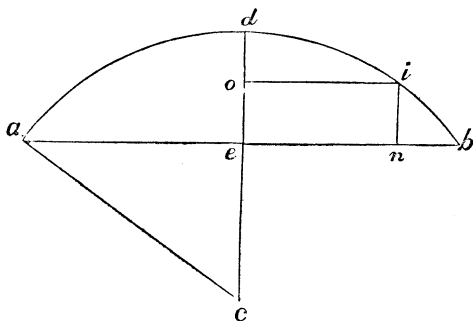
Having the middle ordinate $d\ e$, (Fig. 1) it is required to find any other ordinate, as $i\ n$.

RULE 5.

Subtract the middle ordinate $d\ e$, from the radius $a\ c$, the remainder will be $e\ c$; from the square of the radius $a\ c$, subtract the square of the distance $o\ i$

or *e n*, and extract the square root of the remainder; this square root will be *o c*; subtract *e c* from *o c*; the remainder will be *o e*, which is equal to *i n*, the required ordinate.

EXAMPLE.— The middle ordinate *d e* (Fig. 1) of a 100 ft. chord *a b*, to a radius of 819 ft. = 1·52; it is required to find the length of the ordinate *i n* 20 ft. from the middle one *d e*.

STATEMENT.— 819 — 1·528 = 817·472.

Again, $819^2 = 670761 - 20^2 = \sqrt{670361} = 818·756$ = *o c* — 817·472 = 1·284, will equal *o e* or *i n*, the required ordinate.

To find middle ordinate approximately. Chord 100 ft.

RULE 6.

Multiply the ordinate of a 1° curve by the deflexion angle of 100 ft. This rule is sufficiently close for curves of not less than 500 ft. radius.

2d. Multiply the chords together, and divide by twice the radius.

Fig. 2.
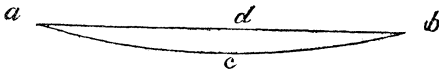
To find the ordinate for a railroad bar *a c b* (Fig. 2) 24 ft. long.

RULE 7.

Multiply one-half the length of the rail by one-fourth its length, and divide by the radius.

EXAMPLE.— Rail 24 ft. long, radius 5730.

STATEMENT.— $24 \div \frac{1}{2} = 12 = \frac{1}{2}$ the length of rail.
$\quad\quad\quad\quad 24 \div \frac{1}{4} = \;\; 6 = \frac{1}{4}$ the length of rail.
Then $6 \times 12 = 72 \div 5730 = 0\cdot01$, ordinate required.

2d. Take one-fourth of the square of the length of the rail, and divide it by twice the radius.

An approximate rule for calculating the middle ordinate of a sub-chord, when the middle ordinate is given.   (Chord 100 ft.)

RULE 8.

As the square of the length of the whole chord is to the square of the length of the sub-chord, so is the middle ordinate of the chord to the middle ordinate of the sub-chord.

EXAMPLE.— Chord 100 ft., middle ordinate ·218, what will be the middle ordinate of the sub-chord 50 ft.?

STATEMENT.— $100^2 : 50^2 : : \cdot218 : \cdot0545.$

Fig. 3.

In running a curve for track, after the grading is done, it is necessary to put in intermediate ordinates, if the curve exceeds 1°; (Fig. 3) these intermediates are from 10 to 20 ft. apart, and instead of running these intermediates with an instrument, the best

method is, after your points are put in with an instrument 100 ft. apart, to draw a small cord or twine, as a b, and measure off your ordinates with a graduated rod, or with the leveling rod.

NOTE.— Refer to Rule 1, page 19 for intermediates or to table.

When the chord and radius are given, to find middle ordinate.   (Chord 100 ft.)

RULE 9.

Divide the square of the chord by eight times the radius.

DEFLEXION DISTANCE.

To find the deflexion distance for 100 ft., with any given radius.

RULE 1.

The square of the chord divided by the radius.

RULE 2.

Divide the constant number 10,000 (chords 100 ft.) by the radius in feet, equals deflexion distance.

To find the deflexion distance for any given radius for chords of 100 ft.

RULE 8.

Divide the given chord by radius, will give the nat. sine of the deflexion angle, which, multiplied by the chord, will equal the required distance.

NOTE.—The tangential distance for 100 ft. is equal to one-half the deflexion distance, and the tangential angle is always equal to one-half the deflexion angle.

Fig. 1.

In putting in curves by deflexion distances it is quite necessary, for accuracy, to measure both on the line of deflexion and chord of the arc, as *a b* and *a c*, (Fig. 1) by first finding your point *b*, and swinging your chain to *c*, and measuring your deflexion distance on the line *b c*.

In commencing your curve on the tangent *e d* you

measure your distance $f\,d$, and lay off $a\,d$ equal to one-half $b\,c$, or one-half the deflexion distance, as $a\,d$ is the tangential distance, and the tangential distance is equal to one-half the deflexion distance.

If you wish to put in intermediates, as it frequently occurs, at the end of a curve.

RULE 4.

Find your deflexion distance for 100 ft., string a line, and put in the required ordinate.

To find the deflexion distance for any number of feet less than 100.

RULE 5.

Take the deflexion distance for 100 ft. and multiply it by the required chord, and divide the product by the length of the whole chord, 100 ft., and subtract the ordinate corresponding in feet and degree.

EXAMPLE.—We wish to get the deflexion distance for 25 ft., for a 15° curve.

STATEMENT.—Deflexion distance equals 26·11 ft., therefore:

$26\cdot11 \times 25 = 652\cdot75 \div 100 = 6\cdot5275.$

Now the ordinate of a 15° curve for 25 ft. = 2·462, and $6\cdot5275 - 2\cdot462 = 4\cdot0655$, deflexion distance for 25 ft.

NOTE.—The above Rule is sufficiently close for all practical work.

Where it is required to find the deflexion or tangential distance for more than 50 ft., subtract the distance to be found from 100, and find the ordinate corresponding to the remainder in feet.

3

To find the deflexion point for any number of feet, at commencement of curves and ending, where the distance is less than 100 ft.

RULE 6.

In commencing a curve, multiply the tangential distance in feet by the number of feet in the chord you wish to find, and divide the product by the length of the whole chord, 100 ft., and measure the distance on the end of a 100 ft. chord; then a line drawn from this point to the *P. C.*, the length of the chord measured you desire to find, on this line, is the point of deflexion.

RULE 7.

To end your curve: Take half the deflexion distance for 100 ft., then multiply the remaining distance (which is the tangential distance,) by the number of feet you wish to find, and divide the product by the length of the whole chord, 100 ft., and measure on the tangential distance, the distance just found; then string a line from this point to the last station given, and measure, on this last given line, the distance required, will give the *T. P.* or *E. C.*

To form a tangent to the curve: Measure as many feet more on the tangential distance, and a line drawn from the last given point to *T. P.* or *E. C.* will be the course of the tangent.

EXAMPLE TO RULE 6.— Suppose in commencing a curve we wish to find the deflexion distance of 25 ft. as at *r*, (Fig. 2) for a 15° curve.   We take the tangential distance *c f* and multiply it by 25 ft., and divide by 100 ft., (the length of the whole chord,) will equal the distance *c s*; now if we measure in the

line *b s* 25 ft. from *b* to *r*, at *r* will be the required point. We then measure 100 ft. from *r* to *d*, in line with *b r*, and measure the deflexion distance *d e*, equal to twice *c f*, for our next full station. We then measure 100 ft. on the line *r e* from *e* to the point *h*, and measure the distance *h i* for our next station, so on to the last station.

EXAMPLE TO RULE 7.—Suppose in ending our curve we wish to find the deflexion distance for 25 ft., to conclude the curve; (Fig. 2) suppose *i* to be the last station in the curve, and the point *t* 25 ft., to be the *E. C.*; we produce the line *e i* to *k* 100 ft. from *i*, and measure one-half the deflexion distance, *k o = l*, then multiply the distance *k l* by 25 ft., and divide by the length of the whole chord *i k*, 100 ft., will equal the distance *l m*, and on the line drawn from *m* to *i*, 25 ft. measured from *i* to *t*, on this line *i m*, will be the required point. To form a tangent to the point *t*, measure *m y* equal to *l m*, will form the tangent *t n* to the curve.
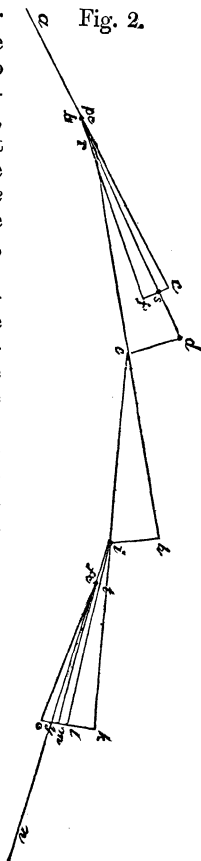
Fig. 2.

TABLE OF DEFLEXION DISTANCES.

Deflexion Angle.	Length o″ Chords in Feet.			
	100	75	50	25
0° 30′	·872	0·572	0·247	0·136
45	1·308	0·899	0·491	0·204
1	1·745	1·144	0·654	0·272
30	2·618	1·717	0·982	0·408
45	3·054	2·003	1·145	0·476
2	3·490	2·290	1·309	0·545
30	4·363	2·863	1·636	0·681
45	4·799	3·419	1·799	0·749
3	5·235	3·435	1.963	0·818
30	6·108	4·008	2·290	0·954
45	6·544	4·295	2·454	1·023
4	6·980	4·581	2·617	1·091
30	7·853	5·153	2·945	1·227
45	8·289	5·440	3·108	1.295
5	8.722	5·723	3·270	1·362
6	10·470	6·870	3·926	1·635
7	12·210	8·011	4·577	1·906
8	13·950	9·152	5·229	2·177
9	15.680	10·286	5·875	2·446
10	17·430	11·435	6·532	2·720
11	19·170	12·575	7·184	2·990
12	20·940	13·738	7·850	3·268
13	22·640	14·848	8·481	3·528
14	24·370	15·980	9·127	3·795
15	26·110	17·120	9·778	4·065

If two lines vary any number of degrees, to find the distance approximately at their extremities.

RULE 8.

Say; If they vary 1·745 in 1° for 100 ft., it will vary thirty times as much in an angle of 30° for

100 ft.; if it is more than 100 ft., make a second statement.

EXAMPLE.—Suppose we have an angle of 30° and 400 ft. long, what is the distance apart at their extremities?

STATEMENT.—As 1° : 30° : : 1·745 : 52·35; 52·35 is the difference for 100 ft.

Then as 100 ft. : 400 ft. : : 52·35 : 209·4, the difference for 400 ft.

Suppose we run a line, on a given course, with the intention of striking a certain point, and find that we deviate from that point, to find the course of the second line that will unite these two points on a straight line.

RULE 9.

Multiply the difference of variation in feet by 57·3,* and divide the product by the length of the line, the quotient either added or subtracted, as necessity requires, will be the course of the line that will unite the two points together.

EXAMPLE.—Suppose the difference of variation = 209·4 ft., and length of line 400 ft., and course N. 29° 59¾′ E., what would be the course of the second line, if the point desired is N. W. of the line run?

STATEMENT.— 209·4 × 57·3 ÷ 400 = 29·9965 = 29° 59¾′.

Then course N. 29° 59¾′ E — 29° 59¾′ = course N. 0° E.

---

* 57·3 is the radius of a circle (nearly) in such parts as the circumference contains 360.

DEFLEXION ANGLE.

To find the deflexion angle corresponding to any given radius.   (Chords 100 ft.)

RULE 1.

Divide the chord by the radius; the quotient will be the natural sine of the deflexion angle; therefore, the number of degrees corresponding to this sine, in the table of nat. sines, equals the deflexion angle.

RULE 2.

The deflexion angle may be found by dividing the radius of a 1° curve, 5730, by the radius in feet, (approximately.)

To find the deflexion angle for any plus distance, or less than 100 ft.

RULE 3.

Multiply one-half the deflexion angle by the plus distance, and divide the product by 100 ft., (length of whole chord,) and add it to one-half the deflexion angle.

EXAMPLE.— Suppose we are running a 15° curve by deflexion distances; we wish to find the deflexion angle for 25 ft.

STATEMENT.— $15° \div 2 = 7° \; 30'$, one-half the deflexion angle.

Then, $7° \; 30' \times 25 = 187° \; 30' \div 100 = 1° \; 52\frac{1}{2}'$.

Then, $1° \; 52\frac{1}{2}' + 7° \; 30' = 9° \; 22\frac{1}{2}'$, deflexion angle for 25 ft.

For deflexion angles corresponding to any given radius, refer to table of radii, page 11.

TANGENTIAL DISTANCE.

To find the tangential distance for any radius, on chords of 100 ft.

RULE 1.

Divide the square of half the chord (50 ft.) by the radius, and multiply the quotient by two.

RULE 2.

Divide the square of the whole chord by twice the radius.

To find the tangential distance for any number of feet less than 100.

RULE 8.

Multiply the tangential distance for 100 ft. by the number of feet required, less than 100 ft., and divide the product by 100 ft., and from the quotient take the ordinate corresponding to the degree of curvature and feet; will equal the tangential distance for the required number of feet, less than 100 ft.

To find the tangential distance for any number of feet.

RULE 4.

Divide the square of the chord given by twice the radius.

In running curves, with equal chords on more than 100 ft., the tangential distances increase as the squares of the number of chords: thus, for 2, 3, 4, 5, 6 chords, 4, 9, 16, 25, 36, multiplied into the tangential distance of 1 chord, will equal each tangential distance respectively.

Or: the square of the length of the chord divided by twice the radius, will equal the tangential distance for any number of feet.

TABLE OF TANGENTIAL DISTANCES.

Deflexion Angle.	Length of Chords in Feet.			
	100	75	50	25
0° 30′	0·436	0·245	0·109	0·027
45	0·654	0·367	0·164	0·040
1	0·873	0·490	0 218	0·054
30	1·309	0·736	0·327	0·081
45	1·527	0·858	0·381	0·095
2	1·745	0·981	0·436	0·109
30	2·182	1·227	0 546	0·136
45	2·399	1·349	0·599	0·150
3	2·618	1·472	0·655	0·163
30	3·054	1·717	0·763	0·190
45	3·272	1·841	0·818	0·205
4	3·490	1·963	0·872	0·218
30	3·927	2·209	0·982	0·246
45	4·145	2·331	1·036	0·259
5	4·361	1·452	1·089	0·272
30	4·798	2·698	1·199	0·299
45	5 015	2·820	1·252	0·312
6	5·235	2·944	1·308	0·326
7	6·105	3·432	1·524	0·380
8	6·975	3·924	1·741	0·433
9	7·840	4·406	1·955	0·486
10	8·715	4·899	2·174	0·541
11	9·585	5·387	2 391	0·594
12	10·470	5·885	2·615	0·650
13	11·340	6·373	2·831	0·703
14	12 210	6·860	3·047	0·755
15	13·080	7·348	3·263	0·808

TANGENTIAL ANGLES.

To find the tangential angle for a chord of 100 ft., with any given radius.

RULE 1.

Divide half the chord by the radius; the quotient will be the natural sine of the tangential angle; and the angle corresponding to this sine, in the table of nat. sines, is the angle required.

To find the tangential angle for any number of feet less than 100 ft.

RULE 2.

Multiply the tangential angle by the number of feet given, and divide the product by the length of the whole chord, (100 ft.)

EXAMPLE.— Suppose we have the tangential angle = 7° 30′, and wish to find the angle for 25 ft.

STATEMENT.— 7° 30′ × 25 ft. ÷ 100 ft. = 1° 52$\frac{1}{2}$′, tangential angle for 25 ft.

Sometimes in running curves it is not necessary to set points in every chord, or 100 ft., and is more expedient, as running curves on a preliminary survey. They can be put in every 2, 3, or 400 ft., as you choose. We wish to find the tangential angle for any number of chords.

RULE 3.

Multiply the tangential angle for 100 ft. by the number of chords you wish to subtend, will equal the tangential angle required.

REMARK.—In running curves, the correct way of measuring with a chain for each station, is to measure around the curve. Instead of this the chain is stretched across, forming a chord; the difference of distance is so comparatively small to a radii of 500 ft., that it is not necessary we should measure around, or make an allowance on the chain; but in running curves with long chords of 3, 4, or 500 ft., it is necessary, for accuracy, to make sufficient allowance, for which I will put in a table of long chords the lengths necessary to subtend from 1 to 4 stations.

TABLE OF LONG CHORDS.

Deflexion Angle.	Length of Chords in Feet required to Subtend.			
	1 Station.	2 Stations.	3 Stations.	4 Stations.
1°	100	200	300	400
2	100	200	299·9	399·7
3	100	200	299·7	399·3
4	100	199·9	299·6	398·9
5	100	199·9	299·2	398·0
6	100	199·7	298·8	397·3
7	100	199·6	298·4	396·2
8	100	199·6	298·0	395·1
9	100	199·4	297·5	394·1
10	100	199·2	297·0	392·4

To find the length of long chords.

RULE 4.

Multiply the natural sine of the tangential angle of the given chord by twice the radius.

EXAMPLE.—The tangential angle for one station = 5°, and radius = 573·7 ft; what would be the length of the chord of four stations?

STATEMENT.—The tangential angle for four stations would equal $4 \times 5° = 20°$, and nat. sine of $20° = \cdot3420201$; twice the radius $= 1147\cdot4 \times \cdot3420201 = 392\cdot4$, length of chord necessary to subtend an arc of four stations.

———————

TRIGONOMETRY.

The angle a given, (Fig. 1) and hypothenuse given, to find the leg $c\ b$.

RULE 1.

By natural sines.—As unity, or one, is to the length of the hypothenuse, so is the natural sine of the smallest angle to the length of the shortest leg.

Fig 1.
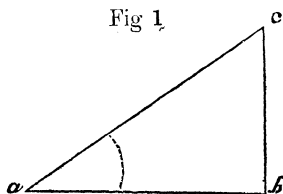
EXAMPLE.— Given the angle $b\ a\ c$ 35° 30', and hypothenuse 25 rods; to find $c\ b$.

STATEMENT.—$1 : 25 : : 0\cdot580703 : 14\cdot5175.$

To find the length of the leg $a\ b$.

RULE 2.

The difference of the sums of the squares of the legs $a\,c$ and $c\,b$, and extract the square root; will equal the leg $a\,b$.

EXAMPLE.— Given the leg $a\,c$ 25 rods, and leg $c\,b$ 14·5175; to find the leg $a\,b$.

STATEMENT.— $\sqrt{25^2 - 14{\cdot}5175^2} = 20{\cdot}35$.

To find the leg $a\,b$, (Fig. 1.)

RULE 3.

By nat. sines.— As unity, or one, is to the nat. sine of the angle $a\,c\,b$, so is the hypothenuse to the leg $a\,b$.

EXAMPLE.— Given the hypothenuse 25 rods, and angle $a\,c\,b$ 54° 30'; to find the leg $a\,b$.

STATEMENT.—1 : 0·8141155 : : 25 : 20·35.

The angles and leg $a\,b$ given, (Fig. 1) to find the hypothenuse $a\,c$, and leg $b\,c$.

RULE 4.

By nat. sines.— As the nat. sine of the angle opposite the given leg $a\,b$ is to the length of given leg, so is unity, or one, to the length of the hypothenuse.

EXAMPLE.— Given the angles $a\,c\,b$ 54° 30', and $b\,a\,c$ 35° 30', and leg $a\,b$ $20\frac{35}{100}$ rods; to find the leg $a\,c$.

STATEMENT.—0·8141155 : 20·35 : : 1 : 25.

Refer to Rule 2, page 38.

To find leg $c\,b$ by nat. sines.

RULE 5.

As the nat. sine of the angle $a\,c\,b$, opposite the given leg, is to the given leg, so is the nat. sine of the angle $b\,a\,c$, opposite the required leg, to the leg $c\,b$.

EXAMPLE.— Given the angle $a\,c\,b$ (Fig. 1) 54° 30', and angle $b\,a\,c$ 35° 30', and leg $a\,b$ $20\frac{35}{100}$ rods; to find the leg $b\,c$.

STATEMENT.—$0{\cdot}8141155 : 20{\cdot}35 :: 0{\cdot}580703 : 14{\cdot}52$, leg $b\,c$.

The hypothenuse and one leg given; to find the angles and the other leg.

RULE 6.

By nat. sines.—The angle opposite the given leg may be found by the following proportion: As the hypothenuse is to unity, or one, so is the given leg to the nat. sine of its opposite angle.

EXAMPLE.— Given the hypothenuse $a\,c$ 25 rods, and leg $a\,b$ 20·35 rods; to find the angles.

STATEMENT.—$25 : 1 :: 20{\cdot}35 : 8141155$, nat. sine of the angle $a\,c\,b$; the nearest corresponding number of degrees and minutes in the table of nat. sines gives the angle $a\,c\,b$ 54° 30', and the angle $a\,b\,c$ being 90°, the angle $b\,a\,c$ would be 35° 30', because in a right-angle triangle there is always 180°.

The leg $a\,c$ given, (Fig. 1) and angle $b\,a\,c$, to find the other leg, $a\,b$, by cosine.

RULE 7.

Multiply the cosine of the angle $b\,a\,c$ by the hypothenuse $a\,c$.

EXAMPLE.— Given the hypothenuse *a c* 25 rods, and angle *b a c* 35° 30′; to find the leg *a b*.

STATEMENT.—0·8141155 × 25 = 20·35, length of the leg *a b*.

The leg *a b* found, (Fig. 1) to find the leg *b c* by nat. tangent.

RULE 8.

Multiply the base by the nat. tangent of the angle opposite the required leg.

EXAMPLE — Given the leg *a b* 20·35, and angle *b a c* 35° 30′; to find the leg *b c*.

STATEMENT.— 0·713293 × 20·35 = 14·5, the required leg *b c*.

The angle *a c b*, and leg *b c*, given, (Fig. 1) to find the leg *a b*, by nat. tangents.

RULE 9.

Multiply the nat. tangent of the angle *a c b* by the leg *b c*.

EXAMPLE.— Given the leg *b c* 14·5, and angle *a c b* 54° 30′; to find the leg *a b*.

STATEMENT.—1·401948 × 14·5 = 20·35, length of leg required, *a b*.

Solution of a Right-angled Triangle.

The sine of the angle *c* equals the cosine of the angle *a*, and the sine of the angle *a* equals the cosine of the angle *c*.

The tangent of the angle *a* equals the cotangent

of the angle *c*, and the tangent of the angle *c* equals the cotangent of the angle *a*.

The leg *a b* divided by the leg *a c* equals the nat. sine of the angle *a c b*, or the nat. cosine of the angle *b a c*; the leg *b c* divided by the leg *a b* equals the nat. tangent of the angle *b a c*, or the nat. cotangent of the angle *a c b*; the leg *b c* divided by the leg *a c* equals the nat. sine of the angle *b a c*, or the nat. cosine of the angle *a c b*.

SURVEYING.

In running lines, obstructions, viz: rivers, ponds, &c., occur, by which other means have to be resorted to, besides measuring with a chain.

Fig. 2.
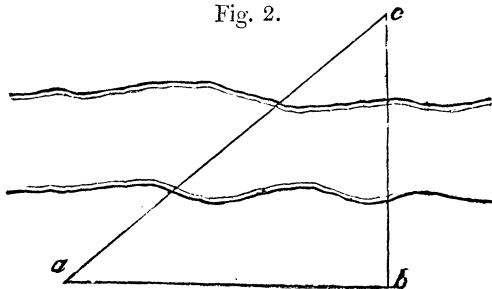
The point *c* occurs on our line *b c*, and we wish to know the distance *b c*.

RULE 10.

From b at right angles to the line $b\ c$ measure any convenient distance, as a, and secure the point a; measure the angle $b\ a\ c$; then multiply the nat. tangent of the angle $b\ a\ c$ by the distance $a\ b$; will equal the distance $b\ c$.

Fig. 3.
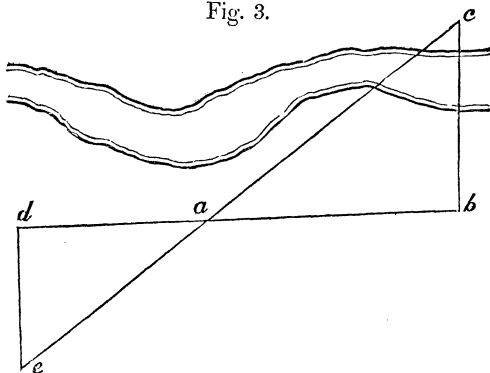
In case you should not have a book of tables of nat. tangents, the above method could be resorted to, with nearly as much accuracy as the method given in Fig. 2.

The point c occurring in the line, (Fig. 3) we wish to know the distance $b\ c$.

RULE 11.

At right angles from $b\ c$ measure on the line $b\ d$ to a, and secure the point a, any convenient point, and measure any convenient distance, as d, and at

right angles describe the line *d e*, with your instrument at *a*, on the line *a c*, produce it to *e*, intersecting the line *d e*.

Then with the distance *b a*, *a d*, and *d e*, given, the distance *b c* can be found proportionately to the triangle *a d e*.

Say: As the distance *a d* is to *a b*, so is *d e* to *b c*.

EXAMPLE.— Given the distance *b a* 20 ft., distance *a d* 15 ft., and distance *d e* $11\frac{1}{2}$ ft.; to find the distance *b c*.

STATEMENT.—As $15:20::11\frac{1}{2}:15\frac{33}{100}$ ft.
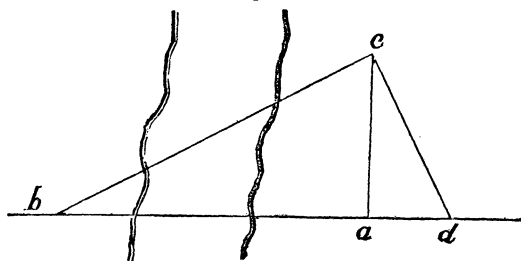
Fig. 4.

The above (Fig. 4) could be resorted to in preference to Fig. 3.

Given *b*, the inaccessible object, and *d b* part of the line of survey; we wish to find the distance from *a* to *b*.

RULE 12.

Measure on the line *a c* (at right angles with *a b*,) any convenient distance, as at *c*; then at right angles

4

to b c run the line c d to its intersection with the line
d b at d, measure the distance a d, and the distance a c.

Then say: The square of a c divided by a d equals
a b, the distance required.

EXAMPLE.— Given a c 26 ft., and a d $13\frac{1}{2}$ ft.; re-
quired the distance a b.

STATEMENT.—$26^2 \div 13\frac{1}{2} = 50$ ft., distance a b.

Fig. 5.
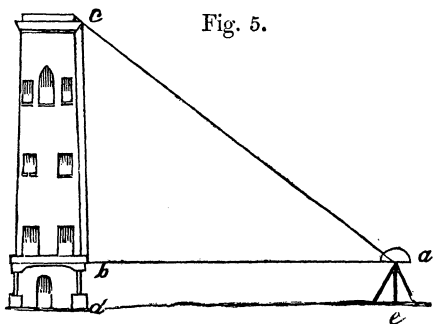
We wish to find the height of a tower, or building,
as d c.

Set your instrument any convenient distance, e,
neither too great nor too small, in comparison to the
altitude d c, and measure the angle b a c, and meas-
use the distance a b or e d; you then have, in the
right-angle triangle, one side given, and the angle b a c.

RULE 18.

Multiply the nat. tangent of the angle b a c by the
distance a b; will equal b c.

NOTE.—The point at *b* can be observed, and afterwards th distance *b d* can be measured, which, added to *b c*, will determine the distance *c d*.

In finding the height of an object, let the observed angle be as near 45° as possible; for then a small error committed in taking it, makes the least error in the computed height of the object; because, if the observed angle, as at *a*, equals 45°, the distance *a b* will equal *b c*.

It very seldom occurs, in the construction of a railroad, to measure verticle heights with an instrument.

In running levels, if the top of a hill is found inaccessible to find the elevation with a leveling instrument, we have to resort to the examples given by triangulation.

Fig. 6
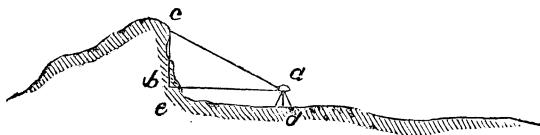
When it is necessary to determine the elevation of a hill as in Fig. 6, the elevation at *d*, is found with the leveling instrument, as will be explained in the Art of Leveling.

EXAMPLE.— Set your instrument over *d*, and measure the angle *b a c*, and distance *a b*; you then have for the triangle *b a c*, the angle and one leg given,

to find the other leg, *b c*, as in Fig. 5; which, added
to the height of your instrument, *a* from *d*, will equal
e c; and added to your elevation *d*, will equal the
elevation *c*.

THE ART OF LEVELING.

The first thing necessary in leveling, is to have the
requisite instruments in adjustment.

To Adjust a Level.

In the common Y level there are three adjustments.

1st ADJUSTMENT.— Place the instrument in a firm
position, and unclamp the Y's; place the horizontal
hairs on some distant object, and revolve the tele-
scope half around; if the hair intersects the point
first observed, the instrument is in adjustment, thus
far; if not, move the hairs half way distant, between
the two points of intersection, by means of the screws
on the telescope, generally marked "Hairs," and by
revolving the telescope, the hairs will intersect our
given point.   The vertical hairs can be adjusted the
same way.

2d ADJUSTMENT.—With the instrument firm, as
before.—Fasten the telescope over the leveling screws,
and level it exact; then take the telescope out of the
Y's and reverse it; if the bubble is level, this adjust-
ment is correct; if not, divide the difference of the

bubble (one-half,) by means of the screws under the bubble, and level the remainder by means of the leveling screws. This process for the second adjustment hardly ever proves correct the first time; therefore, repeat the above, until the telescope, when revolved in the Y's, on every screw, the bubble will be level.

3d ADJUSTMENT.— After the above adjustments, fasten the telescope on the Y's, by means of pins generally used; place your telescope over the leveling screws, and bring the bubble to a level, and repeat it on all the screws, so as to get the telescope as level as possible before commencing the adjustment; then placing the telescope over any two of the leveling screws, and level the bubble; reverse the telescope half way on the pivot, or, as near as possible over the same screws; if the bubble is level, the adjustment is correct, if not, move the bubble half way, by means of the screws under the leg of the Y, and level the remainder by means of the leveling screws. By continuing this process on all the screws, the adjustment can be perfected.

NOTE.—The last adjustment is immaterial, only in saving time and trouble when using. The difference (if there is any,) is so comparatively small, that it is not observable.

The third adjustment never will remain in adjustment on most of levels, so that no trouble need be borrowed when it is found that your level will not reverse correctly. The adjustment of the level now being complete, we will proceed to its use.

In preliminary surveys, or location of railroads,

levels have to be run (as it is termed) to ascertain
the exact surface of the ground, in order to establish
grades. In commencing levels, an elevation is estab-
lished upon a given point. This point is generally
made by cutting on the root of a tree and is termed
a "Bench." These benches are established on the
entire length of the line, perhaps one-half to three-
quarters of a mile apart, for reference points.

This elevation is generally estimated above, so as
to reach the lowest point of the surface of the ground
that should occur in your levels. For instance: The
lowest point of ground we guess to be 50 ft. below
the first established bench, and for safety would call
the bench elevation 60. We set up our level firm
in the ground, not to exceed 400 ft. from the bench,
and near the line we wish to run the levels over, and
take what is termed a back sight (marked B. S.) on
the bench, by holding the staff, or leveling rod, on
the bench, and moving the target of the rod to its
intersection with the horizontal hairs in the telescope;
what the rod would read at this intersection, would
show that our instrument would be that number of
feet and parts above the bench. For instance: Sup-
pose the rod read $3\frac{416}{1000}$ ft., therefore, the elevation of
the instrument would be 63·416.

When we have the height of the instrument given,
it shows very plainly that if you take a sight at any
given point, the elevation would be as much less as
the rod would read. For instance: Suppose the
rod at any point, or station, (as stations of 100 ft. are
used in the location of railroad lines,) should read
$10\frac{198}{1000}$, which are termed fore, or intermediate sight,

(marked F. S.) the elevation of that point taken would be 53·218; or, 63·416 — 10·198 = 53·218; consequently, these fore sights should be subtracted from the height of the instrument, or elevation of the instrument, to give the elevation of stations.* In order to keep up the same corresponding elevations, on the entire length of the line, we change our instrument on some substantial point, as a peg or stone, by holding the rod upon the peg; being a fore sight, we subtract it from the height of the instrument, which gives the elevation of the peg, and is the same as a bench. Suppose the rod reads on the peg 8·747, and instrument is 63·416; 63·416 — 8·747 = 54·669, elevation of peg. †

We have the elevation of the peg, and can move our instrument further on, and set up our instrument firm in the ground, as before, and take a "back sight" on the peg, by holding the rod upon the peg, and notice the reading as before. Suppose the rod to read 1·201; it shows that our instrument is 1 foot and $\frac{201}{1000}$ above the peg; consequently, if we add it to the elevation of the instrument, thus: peg = 54·669, rod reads 1.201 + 54·669 = 55·870, height of instrument, and proceed as before, taking intermediate sights, subtracting every intermediate from the

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* These fore sights are more properly termed intermediate sights (marked I. S.) which we will hereafter term them, and fore sights will be termed as at changes of the instrument, after running the level of intermediates, not to exceed 400 it. on either side of your instrument.

† In practice, whether you change your instrument upon a peg, stone, stump, or anything suitable, it is termed a peg.

height of the instrument. It is not necessary to
carry out the reading of the rod of the decimals,
(when taking intermediates,) farther than hundredths,
as 2·27, 4·15, 8·11, &c., and in most cases tenths is
far enough, as 2·2, 4·1, 8·1, &c., &c.

Intermediates, or plus stations, should be taken
when the ground varies to any amount; discretion
on your own part must govern that. It is evident
that if you were running levels over an uneven
ground, as Fig. 1, and should take the elevation at
station 1 and station 2, that you lose, or there would be
a loss in the estimate of the quantities, or if for the pur-
pose of establishing grades, a correct line could not
be drawn, as a man's discretion is governed by the
correctness of the profile, or levels taken, therefore,
a level should be taken at *a*, also at *b c d*, and the
plus station noted in the book of levels, then you
have the correct shape of the ground.

Fig. 1.
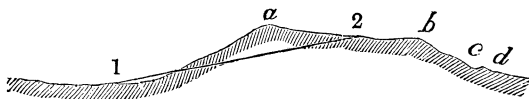
To explain the foregoing more intelligibly, we will
refer to Figs. 2, 3, and 4.

Our established bench elevation 60, is at *A*, on the
root of a stump; our line to run is in the direction of
d, consequently, we would set our level at *c*, not to
exceed 400 ft. from the bench *A*; in directing our
level at the target *f*, we find it reads 3·416; then

our level would be that number of feet and parts above the point *a*; bench elevation is 60, elevation of instrument would be $60 + 3\cdot416 = 63\cdot416$; we will take the elevation of the ground at the stations 1, 2, 3, 4, 5, 6, &c., reading the nearest tenth of a foot, on the rod. Station 1 reads 3·5, therefore, $63\cdot416 - 3\cdot5 = 59\cdot916$, or 59·9 elevation of station 1. Station 2 reads 3·3, then $63\cdot4 - 3\cdot3 = 60\cdot1$. Station 3 reads 3·6, then $63\cdot4 - 3\cdot6 = 59\cdot8$. Station 4 reads 3·7, then $63\cdot4 - 3\cdot7 = 59\cdot7$. Station 5 reads 3·6, then $63\cdot4 - 3\cdot6 = 59\cdot8$. Station 6 reads 3·9, then $63\cdot4 - 3\cdot9 = 59\cdot5$. Station 7 reads 4·8, then $63\cdot4 - 4\cdot8 = 58\cdot6$. Station 8 reads 5·8, then $63\cdot4 - 5\cdot8 = 57\cdot6$. Station 9 reads 8.4, then $63\cdot4 - 8\cdot4 = 55.0$.

Fig. 2.

We will change our instrument at station 9, for convenience. We drive in a peg, firm into the ground, at or near the station; the rod reads 8·747,
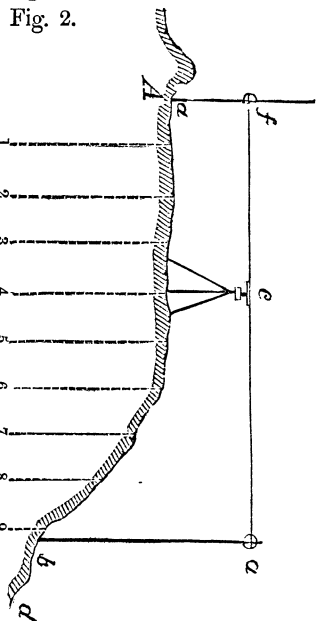
then $63{\cdot}416 - 8{\cdot}747 = 54{\cdot}669$, elevation of the peg at b. This being a secured point, we move our instrument, as in Fig. 3, to f. After firmly setting our instrument, we take a back sight on the peg b. Sup-

Fig. 3.

pose it to read $1{\cdot}201$, the instrument would be that number of feet and parts above the peg. Elevation of the peg we found to be $54{\cdot}669$; the elevation of the instrument would be $54{\cdot}669 + 1{\cdot}201 = 55{\cdot}870$. We now have the elevation of the instrument again. For intermediates, Station 10 reads $2{\cdot}2$, then $55{\cdot}8 - 2{\cdot}2 = 53{\cdot}6$. Station 11 reads $3{\cdot}1$, then $55{\cdot}8 - 3{\cdot}1 = 52{\cdot}7$. Here we should take an elevation at a. Suppose it to be 50 ft. from station 11, as found by measurement; then the plus station would be noted $11 + 50$. Station $11 + 50$ reads $3{\cdot}4$, then $55{\cdot}8 - 3{\cdot}4 = 52{\cdot}4$. Station 12 reads 3.1, then $55{\cdot}8 - 3{\cdot}1 = 52{\cdot}7$. Station 13 reads $2{\cdot}6$, then $55{\cdot}8 - 2{\cdot}6 = 53{\cdot}2$. Station 14 reads $2{\cdot}1$, then $55{\cdot}8 - 2{\cdot}1 = 53{\cdot}7$. Station 15 reads $1{\cdot}8$, then $55{\cdot}8 - 1{\cdot}8 = 54{\cdot}0$. Station 16 reads 2.8, then $55{\cdot}8 - 2{\cdot}8 = 53{\cdot}0$. Station 17 reads $3{\cdot}2$, then $55{\cdot}8 - 3{\cdot}2 = 52{\cdot}6$.

We will change our instrument by driving a peg

at or near station 17, and finding its elevation.*
Suppose the F. S. on the peg reads 3·775, then
height instrument 55·870 — 3·775 = 52·095 = eleva-
tion of peg; we then move our instrument to f, (Fig.
4) and take a B. S. on the peg. Suppose it to read
2·000; elevation peg 52·095 + 2·000 = 54.095 =
height of instrument. Then proceed as before.

Fig. 4.
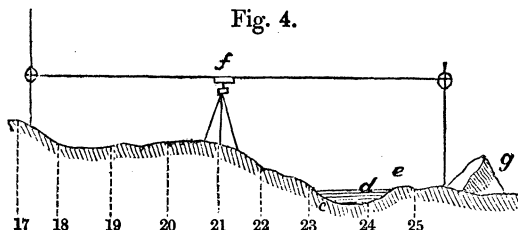
Station 18 reads 3·0, then 54·1 — 3·0 = 51·1.
Station 19 reads 2·9, then 54·1 — 2·9 = 51·2.
Station 20 reads 2·7, then 54·1 — 2·7 = 51·4.
Station 21 reads 2·5, then 54·1 — 2·5 = 51·6.
Station 22 reads 3·6, then 54·1 — 3·6 = 50·5.
Station 23 reads 4·4, then 54·1 — 4·4 = 49·7.

Here at station 23 we have come to a stream, and
it is quite necessary to get its shape, width, and char-
acter. We have got the elevation of the top of the
slope of the river at station 23; we take an elevation
at c, at the bottom of the slope of the creek, and
notice its plus distance from station 23. Suppose it
to be 25 ft.; then 23 + 25 would be the bottom

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* When changing, the elevations should be exact.

slope of the stream.   We also get the elevation of the
bottom of the slope on the opposite side d, and no-
tice the plus station.   Suppose it to be 85 ft. from
station 23, then it would be 23 + 85, bottom slope
of stream; and station 24 would also be taken, as we
very seldom miss stations, wherever they may occur
We have the top slope 23, and two bottom slopes 23
+ 25, and 23 + 85, and to complete the levels of the
creek we want the top slope of opposite side.   Say
it is 75 ft. from station 24; then elevation at 24 +
75 gives the shape of the river's banks and bottom.
Also to govern the masonry, or bridging, over this
stream, the elevation of high water mark is taken.
This will be readily found by inquiry, if no signs on
the banks are visible.

Other very important things have to be observed
and placed under remarks, which your own discretion
must lead you.

We will establish a bench before proceeding far-
ther.   Say, for instance, we cut a notch on the root
of the stump g.   Suppose our rod, or F. S., reads
4·005; height of instrument 54·095 — 4·005 = 50·090,
elevation of the bench.   The elevation of the benches
are generally marked on the stump with either red
chalk or paint.   We secure this elevation at g, and
along the line at intervals, to avoid the trouble of
going back to the first established bench, A, Fig. 2, on
the line.   For instance: Suppose it is required to
find the elevation of station 25, or wished to stake
out a bridge, or stone culvert, in the stream at some
future day.   We, instead of running from the first
established bench, take the established bench g, by

setting our instrument say at *f,* the most convenient
point, and do the work required.

We proceed with our levels as before, and estab-
lish benches, or elevations, not to exceed three-quar-
ters of a mile apart.

It might be necessary to state, for accuracy in
running levels, that the rod should be plumb, or point
to the centre of the earth; also the bubble of the
level should always be level. Accuracy depends
both upon the leveler and rodman.

I will here give the manner of keeping a field-
book for running levels.

Note.—In running levels, always add the back sights,
which will give the elevation of the instrument, and subtract
the fore or intermediate sights, will give the elevation of the
peg or bench.

MANNER OF KEEPING FIELD-BOOK.

NOTES FROM FORMER EXAMPLES.

Sta'n.	B. S.	F. S.	I.S.	H. Inst.	Elev' n.	Remarks.
B'ch	3·416			63·416	60·000	On root of stump near stat'n 1.
1			3·5		59·9	
2			3·3		60·1	
3			3 6		59 8	
4			3·7		59·7	
5			3·6		59·8	
6			3·9		59·5	
7			4·8		58·6	
8			5·8		57·6	
9			8·4		55.0	
Peg.		8·747			54·669	Elevat'n of peg at B. (Fig. 2.)
10	1·201		2·2	55·870	53·6	
11			3·1		52·7	
+50			3·4		52·4	

Stat'n.	B. S.	F. S.	I. S.	H. Inst.	Elevat'n.	Remarks.
12			3·1	63·416	52.7	
13			2·6		53·2	
14			2·1		53·7	
15			1·8		54·0	
16			2·8		53·0	
17			3·2		52·6	
Peg.		3·775			52·095	
18	2·000		3·0	54·095	51·1	
19			2·9		51·2	
20			2·7		51·4	
21			2·5		51·6	
22			3·6		50·5	
23			4·4		49·7	Top of bank of stream.
+25			5·2		48·9	Bottom of stream.
+85			5·3		48·8	Bot. of stream, opposite side.
24			5·0		49·1	
+75			4·4		49·7	Top slope of opposite side.
			4·6		49·5	High water mark.
B'ch		4·005			50·090	On stump by station 26.

In leaving the work at night, benches should be made, so that when you choose at any time to go to work, you have a convenient place to commence, and accurate.

After the levels are run the work is plotted and grades are established.

Grades vary in their ascent according to circumstances, and are governed by the discretion of the engineer in charge. They intend however to equalize the excavation and embankment as near as possible. Grades sometimes can be improved, and are governed by the contracts taken to grade the road.

Grades have elevations as well as the surface of the ground. We will assume the grade at Station

1 to be 58·000 and descent is $0·\frac{22}{100}$ per 100 feet, that it equalizes the excavation and embankment. We then have elevation at

Station	1 = 58·000	Station	13 = 55·360
"	2 = 57·780	"	14 = 55·140
"	3 = 57·560	"	15 = 54·920
"	4 = 57·340	"	16 = 54·700
"	5 = 57·120	"	17 = 54·480
"	6 = 56·900	"	18 = 54·260
"	7 = 56·680	"	19 = 54·040
"	8 = 56·460	"	20 = 53·820
"	9 = 56·240	"	21 = 53·600
"	10 = 56·020	"	22 = 53·380
"	11 = 55·800	"	23 = 53·160
"	12 = 55·580	"	24 = 52·940

With the elevation of the surface of ground, and the elevation of grade, their difference would be the cut or fill. For instance

—— Elevation of the surface Station 1 = 59·9
grade " 1 = 58·0
Difference = 1·9

The difference shows the cutting 1·9 as the surface elevation is the greatest, and at Station 11 Surface elevation = 52·7, Grade elevation 55·8, difference 3·1, fill, as the surface elevation is the least. When the estimates in cubic yards have to be made, (as they are generally made approximately from the profile) the cutting and filling is easily ascertained by calculating the grade for every 100 feet, and taking the difference of elevation as just shown.

When a line is located, the grades are then es-

tablished, and construction commences.   We then
have different field books, termed Grade Book, Cross
Section Book and Monthly Estimate Book.

MANNER OF KEEPING GRADE BOOK.

Sta'n.	Grade.	Cut.	Fill.	Elv'n	Remarks.
1	58·000	1·9		59·9	
2	57·780	2·3		60·1	
3	57·560	2·2		59·8	
4	57·340	2·4		59·7	
5	57·120	2·7		59·8	
6	56·900	2·6		59·5	
7	56·680	1·9		58·6	
8	56·460	1·2		57·6	
9	56·240		1·2	55·0	
10	56·020		2·4	53·6	
11	55·800		3·1	52·7	
+50	55·690		3·3	52·4	
12	55·580		2·8	52·7	
13	55·360		2·1	53·2	
14	55·140		1·4	53·7	
15	54·920		0·9	54·0	
16	54·700		1·7	53·0	
17	54·480		1·8	52·6	
18	54·260		3·1	51·1	
19	54·040		2·8	51·2	
20	53·820		2·4	51·4	
21	53·600		2·0	51·6	
22	53·380		2·9	50·5	
23	53·160		3·4	49·7	Top of bank of stream.
+25	53·105		4·2	48·9	Bottom of stream.
+85	52·973		4·1	48·8	Bottom of stream opposite side.
24	52·940		3·8	49·1	
+75	52·775		3·0	49·7	Top of slope opposite side.

   The benches are all entered in the back part of
the grade book for reference when necessary.   In

the grade book we have the cuts and fills worked out, but in the staking out of the work, these cuts and fills are merely used for tests. Engineers generally have in all their work test points for reference, which all should have, to avoid the many mistakes that will occur.

In staking out work the grade point or where the excavation and embankment commences, is always found with its distance from the station joining, and a stake put in to guide the contractors in commencing their work.

The grade points are generally marked in the cross section book.*

Cross sections are cuts and fills taken at right angles to the line of the road, any distance from the center line that should seem necessary by the engineer.

Cross sections are taken with the level, but more plus stations are taken, than in running levels, as the discretion of the engineer may direct him. Cross sections are taken to get as near as possible the amount of cubic yards excavation and embankment, as contracts are taken of the work, to complete at a given price per cubic yard. On very level ground, cross sections are taken at every station. On very uneven ground cross sections are taken as often as your judgment dictates.

Before proceeding further, we will explain the manner of getting the cuts and fills with a level in the field.

*This cross section book is more properly termed Original Cross Section Book, as there also is the Final Cross Section Book.

5

With the grade book we have the elevation of grade. We go into the field, say at station 21, and set up our level, and take a B. S. on the bench g, (Fig. 4,) and find the elevation of our instrument. Suppose the elevation of the bench to be 50.090, and rod reads 5·112, then 50·090 + 5·112 = 55·202, elevation of instrument. Suppose we wish to commence at station 19, with our cross sections. We would refer to the grade book at station 19 and find the elevation of grade at that point = 54·040. We now have the elevation of our instrument and the elevation of the grade at station 19. Now if we subtract the elevation of the grade from the elevation of the instrument, the difference shows that our instrument is that number of feet and parts above the grade line at station 19. For instance:

$$\text{Elevation of instrument} = 55\cdot202$$
$$\text{grade} = 54\cdot040$$
$$\text{Difference of elevation} = 1\cdot162$$

Then our instrument at station 19 is 1.162 feet above the grade line. We will get the cut or fill at station 19. Suppose our rod to read, at station 19, 4·0, (the nearest tenth of a foot,) it would show our instrument to be four feet above the surface of the ground, and if our instrument is 1·162, (or nearest tenth,) 1·2 above the grade line, and 4·0 above the surface, we see that if we take their differences, it will give the fill or cut at station 19. Then—

$$\text{Elevation of instrument above surface of ground} = 4\cdot0$$
$$\text{grade} = 1\cdot2$$
$$\text{Difference} = 2\cdot8$$

2·8 is then the fill at station 19. We then take our cross section at station 19, subtracting the height of instrument above the grade line, 1·2, from the height of the instrument above the surface, will equal the cut or fill at station 19, any distance at right angles from the station or center line.

We see that our instrument at station 20 (by reference to a profile) would not be 1·162 above the grade line, but would be more as the grade descends. We have found that the grade descends $0 \cdot \frac{22}{100}$ per 100 feet. Then if we add 0·22 to the instrument above the grade line at station 19, will equal its height above the grade line at station 20. Then elevation of instrument at station 19 = 1·162; descends 0·22 per 100 feet, or station, then 0·22 + 1·162 = 1·382; height above station 20 = 1·382.

We will suppose the rod reads at station 20, 4·0, the same as station 19, then 4·0 — 1·4 (nearest tenth of 1·38) = 2·6 fill, or 2 feet and 6 tenth is the difference between the grade line and the surface of the ground at station 20.

We can continue this process to all the stations, until it becomes necessary to change the instrument. When we change, the elevation of the instrument we have preserved = 55·202, and change on a peg, as in running levels, subtracting the sight on the peg for its elevation, and after the instrument is set up again, add the sight to the elevation of the peg, and you have the height of your instrument again, and proceed as you commenced.

Sometimes we find our instrument below the grade line. We will suppose that the rod reads on the

bench g, (Fig. 4,) 2·950; this added to the bench would give the elevation of the instrument; bench = 50·090 + 2·950 = 53·040, height of instrument. Grade at station 19 = 54·040. Now we have the elevation of the instrument, less than the elevation of the grade —

Thus, elevation of instrument = 53·040
      "   grade at stat. 19 = 54·040
        Difference of elevation = 1·000

Shows that our instrument is 1 foot below the grade line. Now if our instrument is below grade, the sights on the surface must be added to the elevation of the instrument, to give the difference or distances of the grade line to the surface. Suppose the rod, or sight, at station 19, reads 1·8. We would see that the surface of ground was 1 foot and 8 tenths below the instrument, and the instrument is 1 foot below the grade line, therefore the distance from the grade line to the surface of the ground, would be their sum. Thus,

Elevation of instrument below grade = 1·00
     "   "   above surface = 1·8
Difference of surface and grade line = 2·8

2·8 would be the fill at station 19.

When you come to grade, the elevation of the instrument above the grade line, and its elevation above the surface of the ground, will be equal.

For example, suppose the instrument be 1·2 above the grade line, and surface of the ground 1·2, the difference is 00, and is the point of grade.

If the elevation of the surface and elevation of grade are equal at any point, that part of the surface

of the ground is grade, or the point where the exca-
vation and embankment commences.   Thus,

Elevation of grade = 54·040
Elevation of surface of ground = 54·040
Difference =   0·00

In taking cross sections, the elevation of the instru-
ment should be preserved for changing — and to be
correct, you should keep a table of both your eleva-
tion of peg and instrument and height of instrument
above the grade line at each and every station.   To
show more plainly, we will make a sketch of the
work already done:

Bench = 50·090
B. S. =   5·112
———————
H. Inst. = 55·202
Change Inst., F. S. =   2·211
———————
Peg = 52·991
B. S. =   0·049
———————
H. Inst. = 53·040

Also,— Grade at stat. 19 = 54·040
H. Inst. = 55·202

H. Inst. at stat. 19, above grade line =   1·162 +
Grade descends 0·22 per 100 feet =   0·22
———————
H. Inst. at stat. 20, above grade line =   1·382 +
0·22
———————
H. Inst. at stat. 21, above grade line =   1·602 +
0·22
———————
H. Inst. at sta. 22, above grade line =   1·822 +
&c., &c.   Change instrument.

We have the height of instrument again, 53·040, and will commence at station 19 again to show the manner of keeping notes with the instrument below grade:

$$\begin{aligned} \text{Grade at stat. } 19 &= 54\text{·}040 \\ \text{H. Inst.} &= 53\text{·}040 \end{aligned}$$

$$\begin{aligned} \text{H. Inst. at sta. } 19 &= \; 1\text{·}000\text{—} \\ \text{``} \qquad \text{``} \quad 20 &= \; 0\text{·}780\text{—} \\ \text{``} \qquad \text{``} \quad 21 &= \; 0\text{·}560\text{—} \\ \text{``} \qquad \text{``} \quad 22 &= \; 0\text{·}340\text{—} \end{aligned}$$

The sign of plus and minus can be annexed to the above, to show that the instrument is above or below grade line. Thus, $+$ = above, $-$ below.

In running from station 19 down the grade, we notice that we add the descent, per 100 feet, to the height of the instrument when plus, and when minus we subtract, because when the instrument is above, the further we run on the descent the greater the height of the instrument from the grade line, as much greater as the descent per 100 feet; and when the instrument is minus, we subtract the descent, because we near the grade line every 100 feet, as the descent of the grade per 100 feet.

Sometimes, in staking out work, it is not necessary

Fig. 5.
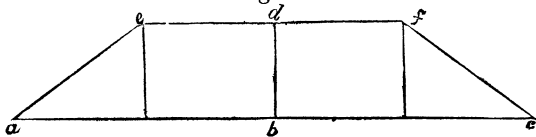
to cross section further than where the slope stakes would occur, as in Fig. 5.

The above shows a cross section, $a\ b\ c$, with the slopes $a\ e\ f\ c$, determined, and slope stakes $a\ c$ put in.

The slope of a railroad is governed by the material of which it is composed.

The excavations are governed the same as the slopes of embankments; the width at the top is governed by the width of track or material. We will assume it to be 14 feet.

In making a cross section of the above, we will assume slopes of $1\frac{1}{2}$ feet horizontal to one foot vertical, as the required slopes. Suppose we take a level at b, (surface of the ground and center of the road,) and find the fill to be four feet. We mark the stake b with red chalk, "4 feet fill," (this is to guide the contractor,) and measure out from b, on either side towards a, one-half the width of the road bed, 7 feet, and take the cutting or filling. From this filling, we can judge of the point for a slope stake a, if the ground does not vary too much; if it should, we keep trying until the exact point for the slope stake is found. For example, we take the level at a, and find that there is $3 \cdot \frac{3}{10}$ feet filling, and, by calculation, slopes $1\frac{1}{2}$ to 1, we measure from the center 7 feet, and base of slope $5 \cdot \frac{7}{10}$, making in all to measure from the center line, (as one end of the tape or chain should always be kept at the center stake to avoid confusion in changing from one side to the other,) would equal $12 \cdot \frac{7}{10}$. We take another sight if it varies much from the point in which we took our sight, and make the same calculations again. It may vary

2 or 3 tenths in the distance from the point last found, but if the ground is level, or nearly so, the required distance can be measured for the slope stake. You go through the same process on the opposite side for the slope stake *c*. We now see that if the contractor fills in 4 feet at *b* to *d*, and 7 feet from *d* to *e*, and 7 feet from *d* to *f*, and carries the dirt out to the slope stakes *a* and *c*, that the slope of the cross sections would have 1½ feet horizontal to 1 foot vertical. Slopes more general in use are 1½ feet horizontal to 1 vertical; 2 feet horizontal to 1 vertical; 1 horizontal to 1 vertical. Calculations for slopes will be found in the following rules:

Slopes 1½ to 1.—With the filling or cutting given, to find the length of the base of the slope.

RULE 1.

One half the cut or fill added to the cut or fill where it is taken.

EXAMPLE.—Given the filling 3·8, to find the base of the slope.

STATEMENT.—½ of 3·8 = 1·9 + 3·8 = 5·7.

Slope 2 to 1.—With the filling or cutting given as before, to find the base of the slopes.

RULE 2.

Multiply the cutting or filling by 2.

EXAMPLE.— Given the filling 3·8 to find the base of the slope = 3·8 × 2 = 7.6.

Slope 1 to 1—

RULE 8.

The base is equal to the filling or cutting.

EXAMPLE.— Given the filling or cutting 3·8; then the base would equal 3·8.

CROSS SECTIONS.

The number of cross sections to be taken will be as the engineer's judgment governs him, but we will give a few examples necessary to correctness in side hill ground entering from a cut to a fill. The following figures 6, 7 and 8 will represent the cross sections.

In leaving the cut (Fig. 6) a cross section should be taken where the grade point occurs at the bottom slope as at *a*, also a cross section should be taken (Fig. 7) where the grade point occurs at the center B; also where the grade point occurs on the opposite side *c*. (Fig. 8.)

Cross sections taken in this manner, give the shape of the ground as near as can be got at. We also have them in plane figures. The area of Fig. 6 to correspond with the area B *c d* (Fig. 7) and Pyd *a B e*, also the Pyd *B c d*, the area *a B e* to correspond with the area *a b c* (Fig. 8). The quantities in this manner are got as correct as is possible. Cross sections around curves should not exceed 50 ft. apart when the average form is used for calculating quantities.

Henck gives a formula for estimating the quantities in curves, but it has been adopted only by a very few engineers, if any. My mode is most in practice

by eminent engineers at present, but there is no
doubt that the manner in which Henck and also
Trautwine do their work will come into general
practice, as the immense quantities of earth that is
estimated by the average form would be very ma-
terially diminished.
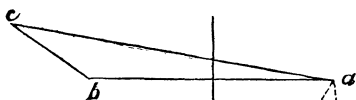
Fig. 6.

Fig. 7.
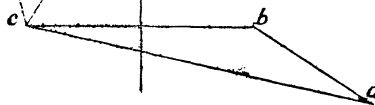
Fig. 8.

BORROWING PITS

Consist of borrowed earth from a hill or side of a mountain, when the earth in the cut is not sufficient for the embankments.

It very often occurs where earth has to be borrowed to finish up embankments; sometimes it is taken from ditches; sometimes knolls are cut off, and sometimes it is taken out of the side of hills and mountains. This amount taken out has to be ascertained in cubic yards.

The Manner of Measuring Borrowing Pits, to ascertain the Quantities taken out.

The object in the first place, is to make original surveys or cross sections; and secondly to make cross sections, (after the earth is taken out) to correspond with the original cross sections. In order to do this, points must be established in the original survey, that can be referred to when you wish to make the second survey. Sometimes it has to be measured monthly, to make monthly estimates.

In order to get correct measurements we will establish a line, (called a Base Line) along the base of the hill* between two points, that will cover the length of the area. For security, the points we will establish upon the roots of some stumps, and in a direct line between these two points, put in stations and plus stations as often as is considered necessary. From these stations, at right angles to the established

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* This is governed altogether by the engineer's judgment.

line, measure with the tape or chain, and where it is necessary take sights with the level, and ascertain the elevation, or cut or fill above a certain given point. Continue on this measurement and elevations back as far as will cover the area to be excavated in that direction; continue the same process at every station and plus station. The notes will be entered in the original cross section book.

If it is necessary to make a monthly estimate, the base line is found, and stations and plus stations are put in as before, and measurements are commenced as before. This is entered into the monthly cross section book.

When the work is completed, a final measurement has to be made, by finding the base line, and proceed as in making the original survey.

These elevations are taken with the level. A base line of levels is established for the pit, and when sights are taken, the notes show the elevation of the ground, either above or below the established base line of levels. When the last survey is made, where the earth has been taken out, the difference of elevation at their corresponding points would show the depth of earth taken at these points.

When those measurements are made, they are plotted upon paper, which will show the area of the cross section.

For example, suppose $a\ b$ (Fig. 9) to be the base line of levels.

The original levels commence at the base line of stations, 1 foot 5 tenths above the base line $a\ b$, and at the top of the hill, or the extent of excavation, the

elevation is 13 feet 4 tenths above the base line.
When the second measurement is made, we find at
the station to be the same as the original, 1 foot 5

Fig. 9.
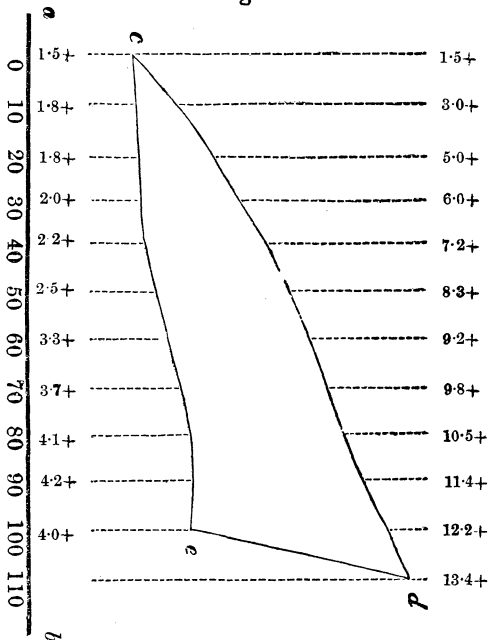
tenths, and find the last point to be 4 feet above the
base line. The excavation we find at the top to be

110 feet from the point at c, and at the bottom, e, or second survey, 100; this will make the slope $d\,e$, and complete the area $c\,d\,e$.

The depth of excavation can be ascertained by the difference of the elevations.

For instance, the depth of cutting 80 feet from the station c equals the difference of the elevations 4·1 and 10·5 = 6·4; the cutting then at 80 feet distance is 6 feet 4 tenths. The remainder of the area is ascertained in the same manner. In the notes the sign of $+$ is annexed to the sights when above the base line of levels, and $-$ when below.

If in two corresponding sights or elevations, one should be below the base line of levels and the other above, the depth of excavations would equal their sum.

If in two corresponding sights or elevations, both should be below the base line of levels, their difference would equal the depth of excavation; if both should be above, their difference would equal the depth of excavations.

NOTE.— All horizontal measurements, with a tape or chain, either in measuring for cross sections or land, should be measured perpendicular to the center of the earth.

The area of the cross sections (Fig. 9) is easily determined, as the original elevations and final elevations correspond in their distance from the station c. It is not always that cross sections can be taken with equal distances (10, 20, 30 feet, &c.) from the station, as the ground may be very irregular both in the original and final measurement. The area of the section is ascertained by calculating the area of the

original measurement to the base line of levels, and
the area of the final measurement to the base line of
levels; the difference of these areas would be the
area of the section.
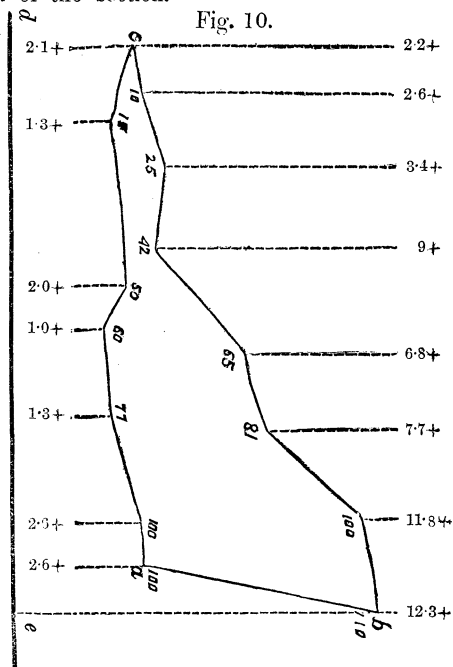
Fig. 10.

For example, to ascertain the area of section *a b
c*, (Fig. 10.)

Instead of the distances 10, 20, 30, &c., from the station at c, we have been obliged (on account of the unevenness of ground) to measure the distances 10, 25, 42, 65, 81, 100 and 120 from the station c, and in the final the distances 15, 50, 60, 77, 100 and 110. In this case the depth of excavation cannot be ascertained, but the area is easily found.

We wish to get the area of the section $a\ b\ c$. By computing the area $b\ c\ d\ e$, and area $b\ e\ d\ c\ a$, the difference of their areas would equal the area $a\ b\ c$.

The manner of keeping original cross section book and final cross section book, is similar. For example, we will arrange Fig. 9 and Fig. 10, supposing that Fig. 9 = stations 1, and Fig. 10 = stations 1 + 20.

<div align="center">ORIGINAL CROSS SECTIONS.</div>

<div align="center">Stations 1.</div>

1·5+ 3·0+ 5·0+ 6·0+ 7·2+ 8·3 + 9·2+ 9·8+ 10·5+ 11·4+ 12·2+ 13·4+
　　10　20　30　40　50　60　70　80　90　100　110

<div align="center">Station 1 + 20.</div>

2·2+ 2·6+ 3·4+ 2·9 + 6·8+ 7·7 + 11·8+ 12 3+
　　10　25　42　65　81　100　120

<div align="center">FINAL CROSS SECTIONS.</div>

<div align="center">Station 1.</div>

1·5+ 1·8+ 1·8+ 2·1+ 2·2+ 2·5+ 3 3+ 3·7+ 4·1+ 4·2+ 4·0+
　　10　20　30　40　50　60　70　80　90　100

<div align="center">Station 1 + 20.</div>

2 2+ 1·3+ 2·0+ 1·0+ 1·3+ 2·6+ 2·6+
　　15　50　60　77　100　110

Base Line or Center.

When the above is plotted, it forms the figures 9 and 10.

The number of cubic yards contained between

these two figures (according to the present mode of calculation) is equal to one-half the sum of their areas, multiplied by the distance they are apart, (20 feet,) and the quotient divided by 27.

MENSURATION OF SURFACES.

To find the area of a right-angled triangle.

RULE 1.

Multiply one-half the base by the perpendicular height, equal the area.

To find the area of a triangle.

RULE 2.

Multiply the base by the perpendicular let fall on to it from the opposite angle, and one-half the product equals the area.

To find the area of a triangle by its sides.

RULE 3.

From half the sum of the three sides subtract each side separately; then multiply the half sum and the three remainders continually together, and the square root of the product will equal the area.

To find the area of a rectangle or a square.

6

RULE 4.

Multiply the perpendicular height by the length, equal the area.

To find the area of a rhombus or a rhomboid.

RULE 5.

Multiply the length by the perpendicular distance let fall from its sides, equals the area.

To find the area of a trapezoid.

RULE 6.

Multiply one-half the sum of the parallel sides by the perpendicular, equals area.

To find the area of a trapezium.

RULE 7.

Multiply the diagonal by the sum of the two perpendiculars falling upon it from the opposite angles, and half the product equals area.

To find the area of a regular polygon.

RULE 8.

Multiply one of its sides into half its perpendicular distance from the center, and this product into the number of sides, equals its area.

To find the area of an irregular polygon.

RULE 9.

Draw diagonals to divide the figure into trapeziums and triangles; find the area of each separately, and the sum of the whole equals area.

To find the area of a long irregular figure, bounded on one side by a straight line, (Figs. 9 and 10 on borrowing pits.)

RULE 10.

Multiply one-half the sum of each succeeding height by their distance apart, the product will be the area between the two heights, the sum of all the areas will equal the area of the figure.

To find the area of a circle when the diameter and circumference are both known.

RULE 11.

Multiply the square of the diameter by ·7854, or the square of the circumference by ·07958; or multiply the circumference by the diameter, and divide the product by 4, will equal area; or one-half the circumference by one-half the diameter.

To find the area of a sector of a circle.

RULE 12.

Multiply the length of the arch by the radius of the circle, and half the product will equal the area, (nearly.)

To find the area of a segment of a circle.

RULE 13.

Multiply the versed sine by the decimal ·626; to the square of the product add the square of half the chord; multiply twice the square root of the sum by two-thirds of the versed sine, will equal area.

To find the area of an ellipsis.

RULE 14.

Multiply the transverse or longer diameter by the conjugate or shorter diameter, and by ·7854,* will equal area.

To find the area of a circular ring or space included between two concentric circles.

RULE 15.

Add the inside and outside diameters together, multiply the sum by their differences, and by ·7854, will equal area.

To find the area of a parabola or its segment.

RULE 16.

Multiply the base by the perpendicular height, and two-thirds of the product equals area.

————————

MENSURATION OF SOLIDS.

To find the solid contents of a cylinder.

RULE 1.

Multiply the area of the base by the height of the cylinder, and the product is the solid contents.

To find the solid contents of a cone or pyramid.

————————————————————————

* The area of a circle whose diameter is 1 = 0·7854.

RULE 2.

Multiply the area of the base by the perpendicular height, and one-third of the product will equal the solid contents.

To find the solid contents of a frustum of a cone.

RULE 3.

To the product of the diameters of the two ends add the sum of their squares; multiply this sum by the perpendicular height, and by ·2618;* the product equals contents.

To find the solid contents of a frustum of a pyramid.

RULE 4.

To the sum of the areas of the two ends add the square root of their product; multiply this sum by the perpendicular height, and one-third of the product equals the contents.

To find the solidity of a wedge.

RULE 5.

To the length of the wedge add twice the length of the base; multiply that sum by the height, and by the breadth of the base, and one-sixth of the product equals contents.

To find the solid contents of a prism.

RULE 6.

Multiply the area of the base by the length, equals contents.

---

* The solidity of a cone 1 foot diameter and 1 foot high equals ·2618.

To find the solid contents of a sphere or globe.

RULE 7.

Multiply the cube of the diameter by ·5236; the product equals contents.

To find the solid contents of the segment of a sphere.

RULE 8.

Add the square root of the height to three times the square of the radius of the base; multiply that sum by the height, and by ·5236; the product is the contents.

To find the solidity of a spheroid.

RULE 9.

Multiply the square of the least diameter by the length of the greatest diameter, or a line drawn perpendicular to the least diameter, and by ·5236; the product will be the solidity.

To find the solidity of a segment of a spheroid, when the base is circular or parallel to the revolving axis or least diameter.

RULE 10.

From triple the fixed axis take double the height of the segment; multiply the difference by the square of the height, and by ·5236. Then say, as the square of the fixed axis is to the square of the revolving axis, so is the former product to the solidity.

To find the solid contents of a cylindric ring.

RULE 11.

To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness, and by 2·4674; the product will be the solid contents.

To find the superficial contents of a board or plank.

RULE 12.

Multiply the length by the width.

If the plank or board are of an unequal breadth at the ends.

RULE 13.

Multiply the average width of the ends by the length.

To find the solidity of timber.

RULE 14.

Multiply the length in feet by the square of one-fourth the girth in inches, gives the solidity in cubic feet.

Note.—The above rules No. 12 and 13 only apply when all the dimensions are in feet. When either the length or breadth are given in inches, divide by 12, when all the dimensions are given in inches, divide by 144.

Application to the table of flat or board measure.

Multiply the length by the number in the table corresponding to any given width.

Example. —Given a board $16\frac{1}{2}$ feet in length and $9\frac{3}{4}$ inches in breadth.

The number in the table opposite $9\frac{3}{4}$ inches = ·8125 × $16\frac{1}{2}$ = 13·4 square feet.

TABLE TO FACILITATE THE MENSURATION OF TIMBER, FLAT OR BROAD MEASURE.

Breadth in inches.	Area of a Lineal foot.	Breadth in inches.	Area of a Lineal foot.	Breadth in inches.	Area of a Lineal foot.
$\frac{1}{4}$	·0208	$4\frac{1}{2}$	·3750	$8\frac{3}{4}$	·7292
$\frac{1}{2}$	·0417	$4\frac{3}{4}$	·3958	9	·7500
$\frac{3}{4}$	·0625	5	·4167	$9\frac{1}{4}$	·7708
1	·0834	$5\frac{1}{4}$	·4375	$9\frac{1}{2}$	·7917
$1\frac{1}{4}$	·1042	$5\frac{1}{2}$	·4583	$9\frac{3}{4}$	·8125
$1\frac{1}{2}$	·1250	$4\frac{3}{4}$	·4792	10	·8334
$1\frac{3}{4}$	·1459	6	·5000	$10\frac{1}{4}$	·8542
2	·1667	$6\frac{1}{4}$	·5208	$10\frac{1}{2}$	·8750
$2\frac{1}{4}$	·1875	$6\frac{1}{2}$	·5416	$10\frac{3}{4}$	·8959
$2\frac{1}{2}$	·2084	$6\frac{3}{4}$	·5625	11	·9167
$2\frac{3}{4}$	·2292	7	·5833	$11\frac{1}{4}$	·9375
3	·2500	$7\frac{1}{4}$	·6042	$11\frac{1}{2}$	·9583
$3\frac{1}{4}$	·2708	$7\frac{1}{2}$	·6250	$11\frac{3}{4}$	·9792
$3\frac{1}{2}$	·2916	$7\frac{3}{4}$	·6458		
$3\frac{3}{4}$	·3125	8	·6667		
4	·3334	$8\frac{1}{4}$	·6875		
$4\frac{1}{4}$	·3542	$8\frac{1}{2}$	·7084		

Application of the table of the solidity of timber.
Multiply the area corresponding to the quarter girth in inches by the length in feet.

EXAMPLE.—Given a piece of timber 20 feet long and 12 inches square.

The number opposite 12 inches = 1·000 × 20 = 20 cubic feet.

TABLE TO FACILITATE THE MENSURATION OF THE SOLIDITY OF TIMBER.

1 qr girth in inches.	Area in feet.	1 qr. girth in inches.	Area in feet.	1 qr. girth in inches.	Area in feet.
6	·250	12¼	1·042	19	2·506
6¼	·272	12½	1·085	19½	2·640
6½	·294	12¾	1·129	20	2·777
6¾	·317	13	1·174	20½	2·917
7	·340	13¼	1·219	21	3·062
7¼	·364	13½	1·265	21½	3·209
7½	·390	13¾	1·313	22	3·362
7¾	·417	14	1·361	22⅔	3·516
8	·444	14¼	1·410	23	3·673
8¼	·472	14½	1·460	23½	3·835
8½	·501	14¾	1·511	24	4·000
8¾	·531	15	1·562	24½	4·168
9	·562	15¼	1·615	25	4·340
9¼	·594	15½	1·668	25½	4·516
9½	·626	15¾	1·722	26	4·694
9¾	·659	16	1·777	26½	4·876
10	·694	16¼	1·833	27	5·062
10¼	·730	16½	1·890	27½	5·252
10½	·766	16¾	1·948	28	5·444
10¾	·803	17	2·006	28½	5·640
11	·840	17¼	2·066	29	5·840
11¼	·878	17½	2·126	29½	6·044
11½	·918	17¾	2·187	30	6·250
11¾	·959	18	2·250		
12	1·000	18½	2·376		

Scantling is measured the same as timber, by multiplying the end area by the length.

MISCELLANIES.

The dimensions of the United States standard bushel are 18½ inches inside diameter, and 8 in. deep.

A box 24 inches by 16 inches square, and 28 inches deep, will contain a barrel, 5 bushels.

A box 14 inches by 17 inches square, and 14 inches deep, will contain a half barrel.

A box 26 inches by 15·2 inches square, and 8 inches deep, will contain 1 bushel.

A box 12 inches by 11·2 inches square, and 8 inches deep, will contain one-half bushel.

A box 8 inches by 8·4 inches square, and 8 inches deep, will contain 1 peck.

A box 8 inches by 8 inches square, and 4·2 inches deep, will contain 1 gallon.

A box 7 inches by 8 inches square, and 4·8 inches deep, will contain one-half gallon.

A box 4 inches by 4 inches square, and 4·1 inches deep, will contain 1 quart.

To get the number of bushels in any square crib.

RULE 1.

Find the number of cubic feet in the same, and multiply it by 8 and divide it by 10.

Any area in feet multiplied by 6·232, the product is the number of imperial gallons at one foot in depth; or any area in inches multiplied by 0·4328 = gallons.

Any area multiplied by ·03704 = the number of cubic yards at one foot in depth.

To determine the amount of imperial gallons in a vessel, the shape of an inverted cone.

RULE 2.

The square of the sum of the diameter at the top and bottom, of which subtract the quotient of the top and bottom; multiply the remainder by ·7854, and by one-third the depth = cubic feet; and by 6·232 = imperial gallons.

Note.— This rule applies where the dimensions are all given in feet.

2d. To the product of the inner diameters add the squares of the inner diameters; multiply the remainder by the depth, and by ·2618; divide that by 277·274 = gallons, (nearly.)

Note.— This rule applies where the dimensions are given in inches.

To determine the contents of imperial gallons in a kettle forming the segment of a circle.

RULE 3.

Three times the square of half the diameter in inches at the mouth, added to the square of the depth, and multiplied by the depth, and by ·5236; divide their product by 277·274, equals imperial gallons.

The area of a circle in inches, multiplied by the length or thickness in inches, and by ·263, equals the weight of cast iron in pounds.

The old English ale gallon contains 282 cubic inches, and the United States gallon contains 231.

English Dry Measure.

8·665	cubic inches	=	1 gill.
34·659	"	"	= 1 pint.
69·318	"	"	= 1 quart.
277·274	"	"	= 1 gallon.
554·548	"	"	= 1 peck.
1·2837	"	feet	= 1 bushel.

English Imperial Wine Measure.

1·604	cubic feet	=	1 anker.
2·888	"	"	= 1 runlet.
6·739	"	"	= 1 tierce.
10·109	"	"	= 1 hogshead.
3·478	"	"	= 1 puncheon.
20·218	"	"	= 1 pipe.
40·435	"	"	= 1 tun.

Dimensions of Drawing Paper.

Wove Antiquarian,	4	feet	4	inches by	2	feet	7 inches.
Double Elephant,	3	"	4	"	2	"	2 "
Atlas,	2	"	9	"	2	"	2 "
Columbier,	2	"	9¾	"	1	"	11 "
Elephant,	2	"	3¾	"	1	"	10¼ "
Imperial,	2	"	5	"	1	"	9¼ "
Super Royal,	2	"	3	"	1	"	7 "
Royal,	2	"	0	"	1	"	7 "
Medium,	1	"	10	"	1	"	6 "
Demy,	1	"	7½	"	1	"	3½ "

Manner of Calculating the Natural Sines and Cosines in the Table.

The radius of a circle being 1, it is known the semi-circumference will equal 3·1415926535898, &c. Therefore if we divide it by the number of minutes in a semi-circumference (10800) it will equal the sine of 1 minute = ·0002909 the first seven places in the table.

The natural cosine equals $\sqrt{(1-\text{sine}')} = ·999999\text{-}9577$.

The natural sine and cosine given, the statement would be as follows:

2 cosine 1′ × sine 1′ — 0′ = sine 2′ minute.
2   "   1′ × " 2′ — 1′ = " 3′   "
2   "   1′ × " 3′ — 2′ = " 4′   "
2   "   1′ × " 4′ — 3′ = " 5′   "

This process can be run to any extent.

With the sine of one minute, and cosine of one minute given, statement second would be as follows:

1′ : sine 2′ — sine 1′ : : sine 2′ + sine 1′ : sine 3′
2′ : " 3′ — " 1′ : : " 3′ + " 1′ : " 4′
3′ : " 4′ — " 1′ : : " 4′ + " 1′ : " 5′
4′ : " 5′ — " 1′ : : " 5′ + " 1′ : " 6′

The same statement can be applied for degrees: Thus:

sine 1° : sine 2° — sine 1° : : sine 2° + sine 1° : sine 3°, &c., &c.

The natural sine of any number of degrees of de
flexion with chords of 100 ft. may be found by
dividing the chord by the radius corresponding to
the angle of deflexion in the table of radii.

EXAMPLE.—Given the deflexion angle 3°, radius
corresponding in the table of radii would equal 1910
feet and chord 100 feet.

STATEMENT.—100 ÷ 1910 = 0·052356, natural
sine of 3°.

NATURAL SINES AND TANGENTS

TO A RADIUS 1.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

0 Deg.

'	SINE	TANG	COTANG	COSINE
0	·0000000	·0000000	Infinite	1·000000
1	·0002909	·0002909	3437·746	1·000000
2	·0005818	·0005582	1718·873	·9999998
3	·0008727	·0008727	1145·915	·9999996
4	·0011636	·0011163	859·4363	·9999993
5	·0014544	·0014545	687·5488	·9999989
6	·0017453	·0017455	572·9572	·9999985
7	·0020362	·0020365	491·1060	·9999979
8	·0023271	·0023271	429·7175	·9999973
9	·0026180	·0026180	381·9709	·9999966
10	·0029089	·0029089	343·7737	·9999958
11	·0031998	·0031999	312·5213	·9999949
12	·0034907	·0034907	289·4777	·9999939
13	·0037815	·0037815	264·4408	·9999928
14	·0040724	·0040724	245·5519	·9999917
15	·0043633	·0043633	229·1816	·9999905
16	·0046542	·0046542	214·8576	·9999892
17	·0049451	·0049451	202·2187	·9999878
18	·0052360	·0052360	190·9841	·9999863
19	·0055268	·0055268	180·9322	·9999847
20	·0058177	·0058177	171·8854	·9999831
21	·0061086	·0061086	163·7000	·9999813
22	·0063995	·0063995	156·2590	·9999795
23	·0066903	·0066905	149·4650	·9999776
24	·0069813	·0069813	143·2371	·9999756
25	·0072721	·0072722	137·5075	·9999736
26	·0075630	·0075630	132·2185	·9999714
27	·0078539	·0078540	127·3213	·9999692
28	·0081448	·0081448	122·7739	·9999668
29	·0084357	·0084357	118·5401	·9999644
30	·0087265	·0087266	114·5885	·9999619

Bottom labels: COSINE | COTANG | TANG | SINE — **Deg. 89.**

0 Deg. (continued)

'	SINE	TANG	COTANG	COSINE	'
31	·0090174	·0090177	110·8920	·9999593	29
32	·0093083	·0093083	107·4264	·9999567	28
33	·0095992	·0095999	104·1709	·9999539	27
34	·0098900	·0098900	101·1069	·9999511	26
35	·0101809	·0101811	98·21794	·9999482	25
36	·0104718	·0104720	95·48947	·9999452	24
37	·0107627	·0107630	92·90848	·9999421	23
38	·0110535	·0110540	90·46333	·9999389	22
39	·0113444	·0113450	88·14357	·9999357	21
40	·0116353	·0116360	85·93979	·9999323	20
41	·0119261	·0119270	83·88350	·9999289	19
42	·0122170	·0122180	81·84704	·9999254	18
43	·0125079	·0125089	79·94343	·9999218	17
44	·0127987	·0127999	78·12634	·9999181	16
45	·0130896	·0130909	76·39000	·9999143	15
46	·0133805	·0133819	74·72916	·9999105	14
47	·0136713	·0136729	73·13899	·9999065	13
48	·0139622	·0139639	71·61507	·9999025	12
49	·0142530	·0142549	70·15334	·9998984	11
50	·0145439	·0145459	68·75008	·9998942	10
51	·0148348	·0148369	67·40183	·9998900	9
52	·0151256	·0151279	66·10547	·9998856	8
53	·0154165	·0154189	64·85840	·9998812	7
54	·0157073	·0157099	63·65674	·9998766	6
55	·0159982	·0160009	62·49915	·9998720	5
56	·0162890	·0162919	61·38290	·9998673	4
57	·0165799	·0165829	60·30582	·9998625	3
58	·0168707	·0168739	59·26587	·9998577	2
59	·0171616	·0171649	58·26117	·9998527	1
60	·0174524	·0174559	57·28996	·9998477	0

Bottom labels: COSINE | COTANG | TANG | SINE — **Deg. 89.**

NATURAL SINES AND TANGENTS TO A RADIUS 1.

1 Deg.

'	SINE.	TANG.	COTANG.	COSINE.
0	.0174524	.017455	57.28996	.9998477
1	.0177432	.017746	56.35059	.9998426
2	.0180341	.018037	55.44161	.9998374
3	.0183249	.018328	54.56130	.9998321
4	.0186158	.018619	53.70558	.9998267
5	.0189066	.018910	52.88211	.9998213
6	.0191974	.019201	52.08067	.9998157
7	.0194883	.019492	51.30315	.9998101
8	.0197791	.019783	50.54880	.9998044
9	.0200699	.020074	49.81572	.9997986
10	.0203608	.020365	49.10388	.9997927
11	.0206516	.020656	48.41208	.9997867
12	.0209424	.020947	47.73950	.9997807
13	.0212332	.021238	47.08534	.9997745
14	.0215241	.021529	46.44886	.9997683
15	.0218149	.021820	45.82935	.9997620
16	.0221057	.022111	45.22614	.9997556
17	.0223965	.022402	44.63859	.9997492
18	.0226873	.022693	44.06642	.9997426
19	.0229781	.022984	43.50812	.9997360
20	.0232690	.023275	42.96407	.9997292
21	.0235598	.023566	42.43346	.9997224
22	.0238506	.023857	41.91579	.9997156
23	.0241414	.024148	41.41058	.9997096
24	.0244322	.024439	40.91741	.9997015
25	.0247230	.024730	40.43583	.9996943
26	.0250138	.025021	39.96546	.9996870
27	.0253046	.025312	39.50589	.9996798
28	.0255954	.025603	39.05677	.9996724
29	.0258862	.025894	38.61773	.9996649
30	.0261769	.026185	38.18845	.9996573
'	COSINE.	COTANG.	TANG.	SINE.

Deg. 88.

1 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.0264677	.026477	37.76861	.9996497	29
32	.0267585	.026768	37.35789	.9996419	28
33	.0270493	.027059	36.95600	.9996341	27
34	.0273401	.027350	36.56265	.9996262	26
35	.0276309	.027641	36.17759	.9996182	25
36	.0279216	.027932	35.80055	.9996101	24
37	.0282124	.028223	35.43123	.9996020	23
38	.0285032	.028514	35.06954	.9995937	22
39	.0287940	.028805	34.71511	.9995854	21
40	.0290847	.029097	34.36777	.9995770	20
41	.0293755	.029388	34.02730	.9995684	19
42	.0296662	.029679	33.69350	.9995599	18
43	.0299570	.029970	33.36619	.9995512	17
44	.0302478	.030261	33.04517	.9995424	16
45	.0305385	.030552	32.73026	.9995336	15
46	.0308293	.030843	32.42129	.9995247	14
47	.0311200	.031135	32.11809	.9995157	13
48	.0314108	.031426	31.82051	.9995066	12
49	.0317015	.031717	31.52839	.9994974	11
50	.0319922	.032008	31.24157	.9994881	10
51	.0322830	.032299	30.95992	.9994788	9
52	.0325737	.032591	30.68330	.9994693	8
53	.0328644	.032882	30.41158	.9994598	7
54	.0331552	.033173	30.14461	.9994502	6
55	.0334459	.033464	29.88229	.9994405	5
56	.0337366	.033755	29.62449	.9994308	4
57	.0340274	.034047	29.37110	.9994209	3
58	.0343181	.034338	29.12200	.9994110	2
59	.0346088	.034629	28.87708	.9994009	1
60	.0348995	.034920	28.63625	.9993908	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 88.

7

NATURAL SINES AND TANGENTS TO A RADIUS 1.

2 DEG.   **DEG. 87.**

′	SINE.	TANG.	COTANG.	COSINE.	′
0	.0348995	.034920	28.63625	.9993908	60
1	.0351902	.035212	28.39939	.9993806	59
2	.0354809	.035503	28.16642	.9993704	58
3	.0357716	.035794	27.93723	.9993600	57
4	.0360623	.036085	27.71174	.9993495	56
5	.0363530	.036377	27.48985	.9993390	55
6	.0366437	.036668	27.27148	.9993284	54
7	.0369344	.036959	27.05655	.9993177	53
8	.0372251	.037250	26.84498	.9993069	52
9	.0375158	.037542	26.63669	.9992960	51
10	.0378065	.037833	26.43160	.9992851	50
11	.0380971	.038124	26.22963	.9992740	49
12	.0383878	.038416	26.03073	.9992629	48
13	.0386785	.038707	25.83482	.9992517	47
14	.0389692	.038998	25.64183	.9992404	46
15	.0392598	.039290	25.45170	.9992290	45
16	.0395505	.039581	25.26436	.9992176	44
17	.0398411	.039872	25.07975	.9992060	43
18	.0401318	.040164	24.89782	.9991944	42
19	.0404224	.040455	24.71851	.9991827	41
20	.0407131	.040746	24.54175	.9991709	40
21	.0410037	.041038	24.36750	.9991590	39
22	.0412944	.041329	24.19571	.9991470	38
23	.0415850	.041621	24.02632	.9991350	37
24	.0418757	.041912	23.85927	.9991228	36
25	.0421663	.042203	23.69453	.9991106	35
26	.0424569	.042495	23.53205	.9990983	34
27	.0427475	.042786	23.37177	.9990859	33
28	.0430382	.043077	23.21367	.9990734	32
29	.0433288	.043369	23.05767	.9990609	31
30	.0436194	.043660	22.90376	.9990482	30
′	COSINE.	COTANG.	TANG.	SINE.	′

2 DEG.   **DEG. 87.**

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.0439100	.043952	22.75189	.9990355	29
32	.0442006	.044243	22.60201	.9990227	28
33	.0444912	.044535	22.45409	.9990098	27
34	.0447818	.044826	22.30809	.9989968	26
35	.0450724	.045118	22.16398	.9989837	25
36	.0453630	.045409	22.02171	.9989706	24
37	.0456536	.045701	21.88125	.9989573	23
38	.0459442	.045992	21.74256	.9989440	22
39	.0462347	.046284	21.60563	.9989306	21
40	.0465253	.046575	21.47040	.9989171	20
41	.0468159	.046867	21.33685	.9989035	19
42	.0471065	.047158	21.20494	.9988899	18
43	.0473970	.047450	21.07466	.9988761	17
44	.0476876	.047741	20.94596	.9988623	16
45	.0479781	.048033	20.81882	.9988484	15
46	.0482687	.048325	20.69322	.9988344	14
47	.0485592	.048616	20.56911	.9988203	13
48	.0488498	.048908	20.44648	.9988061	12
49	.0491403	.049199	20.32530	.9987919	11
50	.0494308	.049491	20.20555	.9987775	10
51	.0497214	.049782	20.08719	.9987631	9
52	.0500119	.050074	19.97021	.9987486	8
53	.0503024	.050366	19.85459	.9987340	7
54	.0505929	.050657	19.74029	.9987194	6
55	.0508835	.050949	19.62729	.9987046	5
56	.0511740	.051241	19.51558	.9986898	4
57	.0514645	.051532	19.40513	.9986748	3
58	.0517550	.051824	19.29592	.9986598	2
59	.0520455	.052116	19.18793	.9986447	1
60	.0523360	.052407	19.08113	.9986295	0
′	COSINE.	COTANG.	TANG.	SINE.	′

NATURAL SINES AND TANGENTS TO A RADIUS 1.

3 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·0523360	·052407	19·08113	·9986295	60
1	·0526264	·052699	18·97552	·9986143	59
2	·0529169	·052990	18·87106	·9985989	58
3	·0532074	·053281	18·76775	·9985835	57
4	·0534979	·053572	18·66556	·9985680	56
5	·0537883	·053863	18·56447	·9985524	55
6	·0540788	·054154	18·46447	·9985367	54
7	·0543693	·054445	18·36553	·9985209	53
8	·0546597	·054737	18·26765	·9985050	52
9	·0549502	·055028	18·17080	·9984891	51
10	·0552406	·055319	18·07497	·9984731	50
11	·0555311	·055610	17·98015	·9984570	49
12	·0558215	·055901	17·88631	·9984408	48
13	·0561119	·056193	17·79344	·9984245	47
14	·0564024	·056484	17·70152	·9984081	46
15	·0566928	·056775	17·61055	·9983917	45
16	·0569832	·057066	17·52051	·9983751	44
17	·0572736	·057358	17·43138	·9983585	43
18	·0575640	·057649	17·34315	·9983418	42
19	·0578544	·057940	17·25580	·9983250	41
20	·0581448	·058231	17·16933	·9983082	40
21	·0584352	·058523	17·08372	·9982912	39
22	·0587256	·058814	16·99895	·9982742	38
23	·0590160	·059105	16·91502	·9982570	37
24	·0593064	·059396	16·83191	·9982398	36
25	·0595967	·059688	16·74961	·9982225	35
26	·0598871	·059979	16·66811	·9982052	34
27	·0601775	·060270	16·58739	·9981877	33
28	·0604678	·060562	16·50745	·9981701	32
29	·0607582	·060853	16·42827	·9981525	31
30	·0610485	·061162	16·34985	·9981348	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 86.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·0613339	·061454	16·27217	·9981170	29
32	·0616292	·061746	16·19522	·9980991	28
33	·0619196	·062038	16·11899	·9980811	27
34	·0622099	·062330	16·04348	·9980631	26
35	·0625002	·062622	15·96866	·9980450	25
36	·0627905	·062914	15·89454	·9980267	24
37	·0630808	·063206	15·82110	·9980084	23
38	·0633711	·063498	15·74833	·9979900	22
39	·0636614	·063790	15·67623	·9979716	21
40	·0639517	·064082	15·60478	·9979530	20
41	·0642420	·064375	15·53398	·9979343	19
42	·0645323	·064667	15·46381	·9979156	18
43	·0648226	·064959	15·39427	·9978968	17
44	·0651129	·065251	15·32535	·9978779	16
45	·0654031	·065543	15·25705	·9978589	15
46	·0656934	·065835	15·18934	·9978399	14
47	·0659836	·066127	15·12224	·9978207	13
48	·0662739	·066419	15·05572	·9978015	12
49	·0665641	·066712	14·98978	·9977821	11
50	·0668544	·067004	14·92441	·9977627	10
51	·0671446	·067296	14·85961	·9977433	9
52	·0674349	·067588	14·79537	·9977237	8
53	·0677251	·067881	14·73167	·9977040	7
54	·0680153	·068173	14·66852	·9976843	6
55	·0683055	·068465	14·60591	·9976645	5
56	·0685957	·068757	14·54383	·9976446	4
57	·0688859	·069049	14·48227	·9976245	3
58	·0691761	·069342	14·42123	·9976045	2
59	·0694663	·069634	14·36069	·9975843	1
60	·0697565	·069926	14·30066	·9975641	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 86.

3 Deg.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

4 Deg.

′	SINE.	TANG.	COTANG.	COSINE.
0	·0697565	·069925	14·30066	·9975641
1	·0700467	·070219	14·24113	·9975437
2	·0703368	·070511	14·18209	·9975233
3	·0706270	·070803	14·12353	·9975028
4	·0709171	·071096	14·06545	·9974822
5	·0712073	·071388	14·00785	·9974615
6	·0714974	·071680	13·95071	·9974408
7	·0717876	·071973	13·89404	·9974199
8	·0720777	·072265	13·83782	·9973990
9	·0723678	·072558	13·78206	·9973780
10	·0726580	·072850	13·72673	·9973569
11	·0729481	·073143	13·67185	·9973357
12	·0732382	·073435	13·61740	·9973145
13	·0735283	·073727	13·56339	·9972931
14	·0738184	·074020	13·50979	·9972717
15	·0741085	·074312	13·45662	·9972502
16	·0743986	·074605	13·40386	·9972286
17	·0746887	·074897	13·35151	·9972069
18	·0749787	·075190	13·29957	·9971851
19	·0752688	·075482	13·24803	·9971633
20	·0755589	·075775	13·19688	·9971413
21	·0758489	·076068	13·14612	·9971193
22	·0761390	·076361	13·09575	·9970972
23	·0764290	·076653	13·04575	·9970750
24	·0767190	·076946	12·99616	·9970528
25	·0770091	·077238	12·94692	·9970304
26	·0772991	·077531	12·89805	·9970080
27	·0775891	·077823	12·84955	·9969854
28	·0778791	·078116	12·80141	·9969628
29	·0781691	·078409	12·75363	·9969401
30	·0784591	·078701	12·70620	·9969173
′	COSINE.	COTANG.	TANG.	SINE.

Deg. 85.

4 Deg.

′	SINE.	TANG.	COTANG.	COSINE.
31	·0787491	·078994	12·65912	·9968945
32	·0790391	·079287	12·61239	·9968715
33	·0793290	·079579	12·56599	·9968485
34	·0796190	·079872	12·51994	·9968254
35	·0799090	·080165	12·47422	·9968022
36	·0801989	·080458	12·42883	·9967789
37	·0804889	·080750	12·38376	·9967555
38	·0807788	·081043	12·33902	·9967321
39	·0810687	·081336	12·29460	·9967085
40	·0813587	·081629	12·25050	·9966849
41	·0816486	·081922	12·20671	·9966612
42	·0819385	·082215	12·16323	·9966374
43	·0822284	·082507	12·12006	·9966135
44	·0825183	·082800	12·07719	·9965895
45	·0828082	·083093	12·03462	·9965655
46	·0830981	·083386	11·99234	·9965414
47	·0833880	·083679	11·95037	·9965172
48	·0836778	·083972	11·90868	·9964929
49	·0839677	·084265	11·86728	·9964685
50	·0842576	·084558	11·82616	·9964440
51	·0845474	·084851	11·78533	·9964195
52	·0848373	·085144	11·74477	·9963948
53	·0851271	·085437	11·70450	·9963701
54	·0854169	·085730	11·66449	·9963453
55	·0857067	·086023	11·62476	·9963204
56	·0859966	·086316	11·58529	·9962954
57	·0862864	·086609	11·54609	·9962704
58	·0865762	·086902	11·50713	·9962452
59	·0868660	·087195	11·46847	·9962200
60	·0871557	·087488	11·43005	·9961947
′	COSINE.	COTANG.	TANG.	SINE.

Deg. 85.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

5 DEG.

′	SINE.	TANG.	COTANG.	COSINE.
0	·0871557	·087488	11·43005	·9961947
1	·0874455	·087781	11·39188	·9961693
2	·0877353	·088074	11·35387	·9961438
3	·0880251	·088368	11·31630	·9961183
4	·0883148	·088661	11·27888	·9960925
5	·0886046	·088954	11·24171	·9960669
6	·0888943	·089247	11·20478	·9960411
7	·0891840	·089540	11·16808	·9960152
8	·0894738	·089834	11·13163	·9959892
9	·0897635	·090127	11·09541	·9959631
10	·0900532	·090420	11·05943	·9959370
11	·0903429	·090713	11·02367	·9959107
12	·0906326	·091007	10·98815	·9958844
13	·0909223	·091300	10·95285	·9958580
14	·0912119	·091593	10·91777	·9958315
15	·0915016	·091887	10·88292	·9958049
16	·0917913	·092180	10·84828	·9957783
17	·0920809	·092473	10·81387	·9957515
18	·0923706	·092767	10·77967	·9957247
19	·0926602	·093060	10·74568	·9956978
20	·0929499	·093354	10·71191	·9956708
21	·0932395	·093647	10·67834	·9956437
22	·0935291	·093940	10·64499	·9956165
23	·0938187	·094234	10·61184	·9955892
24	·0941083	·094527	10·57889	·9955620
25	·0943979	·094821	10·54615	·9955345
26	·0946875	·095114	10·51360	·9955069
27	·0949771	·095408	10·48126	·9954794
28	·0952666	·095701	10·44911	·9954517
29	·0955562	·095995	10·41715	·9954240
30	·0958458	·096289	10·38539	·9953962
′	COSINE.	TANG.	COTANG.	SINE.

5 DEG.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	·0961353	·096582	10·35382	·9953683	29
32	·0964248	·096876	10·32244	·9953403	28
33	·0967144	·097169	10·29125	·9953122	27
34	·0970039	·097463	10·26024	·9952840	26
35	·0972934	·097757	10·22942	·9952557	25
36	·0975829	·098050	10·19878	·9952274	24
37	·0978724	·098344	10·16833	·9951990	23
38	·0981619	·098638	10·13805	·9951705	22
39	·0984514	·098932	10·10795	·9951419	21
40	·0987408	·099225	10·07803	·9951132	20
41	·0990303	·099519	10·04828	·9950844	19
42	·0993197	·099813	10·01871	·9950556	18
43	·0996092	·100107	9·989305	·9950266	17
44	·0998986	·100400	9·960072	·9949976	16
45	·1001881	·100694	9·931008	·9949685	15
46	·1004775	·100988	9·902112	·9949393	14
47	·1007669	·101282	9·873382	·9949101	13
48	·1010563	·101576	9·844816	·9948807	12
49	·1013457	·101870	9·816414	·9948513	11
50	·1016351	·102164	9·788173	·9948217	10
51	·1019245	·102458	9·760092	·9947921	9
52	·1022138	·102752	9·732171	·9947625	8
53	·1025032	·103046	9·704407	·9947327	7
54	·1027925	·103339	9·676800	·9947028	6
55	·1030819	·103634	9·649347	·9946729	5
56	·1033712	·103928	9·622048	·9946428	4
57	·1036605	·104222	9·594902	·9946127	3
58	·1039499	·104516	9·567906	·9945825	2
59	·1042392	·104810	9·541061	·9945523	1
60	·1045285	·105104	9·514364	·9945219	0
′	COSINE.	COTANG.	TANG.	SINE.	′

DEG. 84.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

6 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'	SINE.	TANG.	COTANG.	COSINE.	'
0	.1045285	.105104	9.514364	.9945219	31	.1134922	.114230	8.754246	.9935389	29
1	.1048178	.105398	9.487814	.9944914	32	.1137812	.114525	8.731719	.9935058	28
2	.1051070	.105692	9.461411	.9944609	33	.1140702	.114819	8.709307	.9934727	27
3	.1053963	.105986	9.435153	.9944303	34	.1143592	.115114	8.687008	.9934395	26
4	.1056856	.106280	9.409038	.9943996	35	.1146482	.115409	8.664822	.9934062	25
5	.1059748	.106575	9.383066	.9943688	36	.1149372	.115703	8.642747	.9933728	24
6	.1062641	.106869	9.357235	.9943379	37	.1152261	.115998	8.620783	.9933393	23
7	.1065533	.107163	9.331545	.9943070	38	.1155151	.116293	8.598929	.9933057	22
8	.1068425	.107457	9.305993	.9942760	39	.1158040	.116588	8.577183	.9932721	21
9	.1071318	.107751	9.280580	.9942448	40	.1160929	.116883	8.555546	.9932384	20
10	.1074210	.108046	9.255303	.9942136	41	.1163818	.117178	8.534017	.9932045	19
11	.1077102	.108340	9.230162	.9941823	42	.1166707	.117473	8.512594	.9931706	18
12	.1079994	.108634	9.205156	.9941510	43	.1169596	.117767	8.491277	.9931367	17
13	.1082885	.108929	9.180283	.9941195	44	.1172485	.118062	8.470065	.9931026	16
14	.1085777	.109223	9.155543	.9940880	45	.1175374	.118357	8.448957	.9930685	15
15	.1088669	.109517	9.130934	.9940563	46	.1178263	.118652	8.427953	.9930342	14
16	.1091560	.109812	9.106456	.9940246	47	.1181151	.118947	8.407051	.9929999	13
17	.1094452	.110106	9.082107	.9939928	48	.1184040	.119242	8.386251	.9929655	12
18	.1097343	.110401	9.057886	.9939610	49	.1186928	.119537	8.365553	.9929310	11
19	.1100234	.110695	9.033793	.9939290	50	.1189816	.119832	8.344955	.9928965	10
20	.1103126	.110990	9.009826	.9938969	51	.1192704	.120127	8.324457	.9928618	9
21	.1106017	.111284	8.985984	.9938648	52	.1195593	.120423	8.304058	.9928271	8
22	.1108908	.111578	8.962266	.9938325	53	.1198481	.120718	8.283757	.9927922	7
23	.1111779	.111873	8.938672	.9938003	54	.1201368	.121013	8.263554	.9927573	6
24	.1114689	.112168	8.915200	.9937679	55	.1204256	.121308	8.243448	.9927224	5
25	.1117580	.112462	8.891850	.9937355	56	.1207144	.121603	8.223438	.9926873	4
26	.1120471	.112757	8.868620	.9937029	57	.1210031	.121898	8.203523	.9926521	3
27	.1123361	.113051	8.845510	.9936703	58	.1212919	.122194	8.183704	.9926169	2
28	.1126252	.113346	8.822518	.9936375	59	.1215806	.122489	8.163978	.9925816	1
29	.1129142	.113641	8.799644	.9936047	60	.1218693	.122784	8.144346	.9925462	0
30	.1132032	.113935	8.776887	.9935719						
'	COSINE.	COTANG.	TANG.	SINE.		COSINE.	COTANG.	TANG.	SINE.	'

Deg. 83

NATURAL SINES AND TANGENTS TO A RADIUS 1.

7 Deg.

'	SINE.	TANG.	COTANG.	COSINE.
0	.1218693	.122784	8.144346	.9925462
1	.1221581	.123079	8.124807	.9925107
2	.1224468	.123375	8.105359	.9924751
3	.1227355	.123670	8.086004	.9924394
4	.1230241	.123965	8.066739	.9924037
5	.1233128	.124261	8.047564	.9923679
6	.1236015	.124556	8.028479	.9923319
7	.1238901	.124852	8.009483	.9922959
8	.1241788	.125147	7.990575	.9922599
9	.1244674	.125442	7.971755	.9922237
10	.1247560	.125738	7.953022	.9921874
11	.1250446	.126033	7.934375	.9921511
12	.1253332	.126329	7.915815	.9921147
13	.1256218	.126624	7.897339	.9920782
14	.1259104	.126920	7.878948	.9920416
15	.1261990	.127216	7.860642	.9920049
16	.1264875	.127511	7.842419	.9919682
17	.1267761	.127807	7.824279	.9919314
18	.1270646	.128103	7.806221	.9918944
19	.1273531	.128398	7.788245	.9918574
20	.1276416	.128694	7.770350	.9918204
21	.1279302	.128990	7.752536	.9917832
22	.1282186	.129285	7.734802	.9917459
23	.1285071	.129581	7.717148	.9917086
24	.1287956	.129877	7.699573	.9916712
25	.1290841	.130173	7.682076	.9916337
26	.1293725	.130469	7.664658	.9915961
27	.1296609	.130764	7.647317	.9915584
28	.1299494	.131060	7.630053	.9915206
29	.1302378	.131356	7.612865	.9914828
30	.1305262	.131652	7.595754	.9914449
'	COSINE.	TANG.	COTANG.	SINE.

DEG. 82.

7 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.1308146	.131948	7.578717	.9914069	29
32	.1311030	.132244	7.561756	.9913688	28
33	.1313913	.132540	7.544869	.9913306	27
34	.1316797	.132836	7.528057	.9912923	26
35	.1319681	.133132	7.511317	.9912540	25
36	.1322564	.133428	7.494651	.9912155	24
37	.1325447	.133724	7.478057	.9911770	23
38	.1328330	.134020	7.461535	.9911384	22
39	.1331213	.134316	7.445085	.9910997	21
40	.1334096	.134612	7.428706	.9910610	20
41	.1336979	.134909	7.412397	.9910221	19
42	.1339862	.135205	7.396159	.9909832	18
43	.1342744	.135501	7.379990	.9909442	17
44	.1345627	.135797	7.363891	.9909051	16
45	.1348509	.136094	7.347861	.9908659	15
46	.1351392	.136390	7.331898	.9908266	14
47	.1354274	.136686	7.316004	.9907873	13
48	.1357156	.136983	7.300178	.9907478	12
49	.1360038	.137279	7.284418	.9907083	11
50	.1362919	.137575	7.268725	.9906687	10
51	.1365801	.137872	7.253098	.9906290	9
52	.1368683	.138168	7.237537	.9905893	8
53	.1371564	.138465	7.222042	.9905494	7
54	.1374445	.138761	7.206611	.9905095	6
55	.1377327	.139058	7.191245	.9904694	5
56	.1380208	.139354	7.175943	.9904293	4
57	.1383089	.139651	7.160705	.9903891	3
58	.1385970	.139947	7.145530	.9903489	2
59	.1388850	.140244	7.130419	.9903085	1
60	.1391731	.140540	7.115369	.9902681	0
'	COSINE.	TANG.	COTANG.	SINE.	'

DEG. 82.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

8 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.1391731	.140540	7.115369	.9902681	60
1	.1394612	.140837	7.100382	.9902275	59
2	.1397492	.141134	7.085457	.9901869	58
3	.1400372	.141430	7.070593	.9901462	57
4	.1403252	.141727	7.055790	.9901055	56
5	.1406132	.142024	7.041048	.9900646	55
6	.1409012	.142321	7.026366	.9900237	54
7	.1411892	.142617	7.011744	.9899826	53
8	.1414772	.142914	6.997180	.9899415	52
9	.1417651	.143211	6.982678	.9899003	51
10	.1420531	.143508	6.968233	.9898590	50
11	.1423410	.143805	6.953847	.9898177	49
12	.1426289	.144102	6.939519	.9897762	48
13	.1429168	.144399	6.925248	.9897347	47
14	.1432047	.144696	6.911035	.9896931	46
15	.1434926	.144993	6.896879	.9896514	45
16	.1437805	.145290	6.882780	.9896096	44
17	.1440684	.145587	6.868737	.9895677	43
18	.1443562	.145884	6.854750	.9895258	42
19	.1446440	.146181	6.840819	.9894838	41
20	.1449319	.146478	6.826943	.9894416	40
21	.1452197	.146775	6.813122	.9893994	39
22	.1455075	.147072	6.799356	.9893572	38
23	.1457953	.147369	6.785644	.9893148	37
24	.1460830	.147667	6.771986	.9892723	36
25	.1463708	.147964	6.758382	.9892298	35
26	.1466585	.148261	6.744831	.9891872	34
27	.1469463	.148559	6.731334	.9891445	33
28	.1472340	.148856	6.717889	.9891017	32
29	.1475217	.149153	6.704496	.9890588	31
30	.1478094	.149451	6.691156	.9890159	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 81.

8 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.1480971	.149748	6.677367	.9889728	29
32	.1483848	.150045	6.664630	.9889297	28
33	.1486724	.150343	6.651444	.9888862	27
34	.1489601	.150640	6.638310	.9888432	26
35	.1492497	.150938	6.625225	.9887998	25
36	.1495353	.151235	6.612191	.9887564	24
37	.1498290	.151533	6.599208	.9887128	23
38	.1501106	.151830	6.586273	.9886692	22
39	.1503961	.152128	6.573389	.9886255	21
40	.1506857	.152426	6.560553	.9885817	20
41	.1509733	.152723	6.547767	.9885378	19
42	.1512608	.153021	6.535029	.9884939	18
43	.1515464	.153319	6.522339	.9884498	17
44	.1518359	.153617	6.509698	.9884057	16
45	.1521234	.153914	6.497104	.9883615	15
46	.1524109	.154212	6.484558	.9883172	14
47	.1526984	.154510	6.472059	.9882728	13
48	.1529858	.154808	6.459607	.9882284	12
49	.1532733	.155106	6.447201	.9881838	11
50	.1535607	.155404	6.434842	.9881392	10
51	.1538467	.155702	6.422530	.9880945	9
52	.1541356	.156000	6.410263	.9880497	8
53	.1544239	.156297	6.398042	.9880048	7
54	.1547104	.156595	6.385866	.9879599	6
55	.1549978	.156893	6.373735	.9879148	5
56	.1552851	.157191	6.361650	.9878697	4
57	.1555725	.157490	6.349609	.9878245	3
58	.1558598	.157788	6.337612	.9877792	2
59	.1561472	.158086	6.325660	.9877338	1
60	.1564345	.158384	6.313751	.9876883	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 81.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

9 DEG.

′	COSINE.	COTANG.	TANG.	SINE.	′
29	.9862375	5.965104	.167641	.1653345	31
28	.9861894	5.954481	.167940	.1656214	32
27	.9861412	5.943895	.168239	.1659082	33
26	.9860929	5.933345	.168539	.1661951	34
25	.9860445	5.922832	.168838	.1664819	35
24	.9859960	5.912355	.169137	.1667687	36
23	.9859475	5.901913	.169436	.1670556	37
22	.9858988	5.891508	.169735	.1673423	38
21	.9858501	5.881138	.170035	.1676291	39
20	.9858013	5.870804	.170334	.1679159	40
19	.9857524	5.860505	.170633	.1682026	41
18	.9857035	5.850241	.170933	.1684894	42
17	.9856544	5.840011	.171232	.1687761	43
16	.9856053	5.829817	.171532	.1690628	44
15	.9855561	5.819657	.171831	.1693495	45
14	.9855068	5.809531	.172130	.1696362	46
13	.9854574	5.799440	.172430	.1699228	47
12	.9854079	5.789382	.172730	.1702095	48
11	.9853583	5.779358	.173029	.1704961	49
10	.9853083	5.769368	.173329	.1707828	50
9	.9852590	5.759412	.173628	.1710694	51
8	.9852092	5.749488	.173928	.1713560	52
7	.9851593	5.739598	.174228	.1716425	53
6	.9851093	5.729741	.174527	.1719291	54
5	.9850593	5.719917	.174827	.1722156	55
4	.9850091	5.710125	.175127	.1725022	56
3	.9849589	5.700366	.175427	.1727887	57
2	.9849086	5.690639	.175727	.1730752	58
1	.9848582	5.680944	.176027	.1733617	59
0	.9848078	5.671281	.176327	.1736482	60
′	SINE.	TANG.	COTANG.	COSINE.	′

DEG. 80.

9 DEG.

′	SINE.	TANG.	COTANG.	COSINE.	′
0	.1564345	.158384	6.313751	.9876883	
1	.1567218	.158682	6.301886	.9876428	
2	.1570091	.158980	6.290065	.9875972	
3	.1572963	.159279	6.278286	.9875514	
4	.1575836	.159577	6.266551	.9875057	
5	.1578708	.159875	6.254858	.9874598	
6	.1581581	.160174	6.243208	.9874138	
7	.1584453	.160472	6.231600	.9873678	
8	.1587325	.160770	6.220034	.9873216	
9	.1590197	.161069	6.208510	.9872754	
10	.1593069	.161367	6.197027	.9872291	
11	.1595940	.161666	6.185586	.9871827	
12	.1598812	.161964	6.174186	.9871363	
13	.1601683	.162263	6.162827	.9870897	
14	.1604555	.162561	6.151508	.9870431	
15	.1607426	.162860	6.140230	.9869964	
16	.1610297	.163159	6.128992	.9869496	
17	.1613167	.163457	6.117794	.9869027	
18	.1616038	.163756	6.106636	.9868557	
19	.1618909	.164055	6.095517	.9868087	
20	.1621779	.164353	6.084438	.9867615	
21	.1624650	.164652	6.073397	.9867143	
22	.1627520	.164951	6.062396	.9866670	
23	.1630390	.165250	6.051434	.9866196	
24	.1633260	.165548	6.040510	.9865722	
25	.1636129	.165847	6.029624	.9865246	
26	.1638999	.166146	6.018777	.9864770	
27	.1641868	.166445	6.007967	.9864293	
28	.1644738	.166744	5.997195	.9863815	
29	.1647607	.167043	5.986461	.9863336	
30	.1650476	.167342	5.975764	.9862856	
′	COSINE.	TANG.	COTANG.	SINE.	′

DEG. 80.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

10 Deg. — 10 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.1736482	.176327	5.671281	.9848078	60
1	.1739346	.176626	5.661650	.9847572	59
2	.1742211	.176926	5.652051	.9847066	58
3	.1745075	.177226	5.642483	.9846558	57
4	.1747939	.177527	5.632947	.9846050	56
5	.1750803	.177827	5.623442	.9845542	55
6	.1753667	.178127	5.613968	.9845032	54
7	.1756531	.178427	5.604524	.9844521	53
8	.1759395	.178727	5.595112	.9844010	52
9	.1762258	.179027	5.585730	.9843498	51
10	.1765121	.179327	5.576378	.9842985	50
11	.1767984	.179628	5.567057	.9842471	49
12	.1770847	.179928	5.557766	.9841956	48
13	.1773710	.180228	5.548505	.9841441	47
14	.1776573	.180529	5.539274	.9840924	46
15	.1779435	.180829	5.530072	.9840407	45
16	.1782298	.181129	5.520900	.9839889	44
17	.1785160	.181430	5.511757	.9839370	43
18	.1788022	.181730	5.502644	.9838850	42
19	.1790884	.182031	5.493560	.9838330	41
20	.1793746	.182331	5.484505	.9837808	40
21	.1796607	.182632	5.475478	.9837286	39
22	.1799469	.182933	5.466481	.9836763	38
23	.1802330	.183233	5.457512	.9836239	37
24	.1805191	.183534	5.448571	.9835715	36
25	.1808052	.183835	5.439659	.9835189	35
26	.1810913	.184135	5.430775	.9834663	34
27	.1813774	.184436	5.421918	.9834136	33
28	.1816635	.184737	5.413090	.9833608	32
29	.1819495	.185038	5.404290	.9833079	31
30	.1822355	.185339	5.395517	.9832549	30
'	COSINE.	COTANG.	TANG.	SINE.	'

DEG. 79.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.1825215	.186639	5.386771	.9832019	29
32	.1828075	.185940	5.378053	.9831487	28
33	.1830935	.186241	5.369363	.9830955	27
34	.1833795	.186542	5.360699	.9830422	26
35	.1836654	.186843	5.352062	.9829888	25
36	.1839514	.187144	5.343452	.9829353	24
37	.1842373	.187446	5.334869	.9828818	23
38	.1845232	.187747	5.326313	.9828282	22
39	.1848091	.188048	5.317783	.9827744	21
40	.1850949	.188349	5.309279	.9827216	20
41	.1853808	.188650	5.300801	.9826668	19
42	.1856666	.188952	5.292350	.9826128	18
43	.1859524	.189253	5.283925	.9825587	17
44	.1862382	.189554	5.275525	.9825046	16
45	.1865240	.189855	5.267151	.9824504	15
46	.1868098	.190157	5.258803	.9823961	14
47	.1870956	.190458	5.250480	.9823417	13
48	.1873813	.190760	5.242183	.9822873	12
49	.1876670	.191061	5.233911	.9822327	11
50	.1879528	.191363	5.225664	.9821781	10
51	.1882385	.191664	5.217442	.9821234	9
52	.1885241	.191966	5.209245	.9820686	8
53	.1888098	.192268	5.201073	.9820137	7
54	.1890954	.192569	5.192926	.9819587	6
55	.1893811	.192871	5.184803	.9819037	5
56	.1896667	.193173	5.176705	.9818485	4
57	.1899523	.193474	5.168631	.9817933	3
58	.1902379	.193776	5.160581	.9817380	2
59	.1905234	.194078	5.152555	.9816826	1
60	.1908090	.194380	5.144654	.9816272	0
'	COSINE.	COTANG.	TANG.	SINE.	'

DEG. 79.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

11 Deg. (11°31′ – 12°00′) — Deg. 78

′	SINE.	TANG.	COTANG.	COSINE.	′
31	·1996530	·203755	4·907849	·9798667	29
32	·1999380	·204058	4·900562	·9798086	28
33	·2002230	·204361	4·893295	·9797604	27
34	·2005080	·204664	4·886049	·9796921	26
35	·2007930	·204967	4·878824	·9796337	25
36	·2010779	·205270	4·871620	·9795752	24
37	·2013629	·205573	4·864435	·9795167	23
38	·2016478	·205876	4·857271	·9794581	22
39	·2019327	·206180	4·850128	·9793994	21
40	·2022176	·206483	4·843004	·9793406	20
41	·2025024	·206786	4·835901	·9792818	19
42	·2027873	·207090	4·828817	·9792228	18
43	·2030721	·207393	4·821753	·9791638	17
44	·2033569	·207696	4·814709	·9791047	16
45	·2036418	·208000	4·807685	·9790455	15
46	·2039265	·208303	4·800680	·9789862	14
47	·2042113	·208607	4·793695	·9789268	13
48	·2044961	·208910	4·786730	·9788674	12
49	·2047808	·209214	4·779783	·9788079	11
50	·2050655	·209518	4·772856	·9787483	10
51	·2053502	·209821	4·765949	·9786886	9
52	·2056349	·210125	4·759060	·9786288	8
53	·2059195	·210429	4·752190	·9785690	7
54	·2062042	·210733	4·745340	·9785090	6
55	·2064888	·211036	4·738508	·9784490	5
56	·2067734	·211340	4·731695	·9783889	4
57	·2070580	·211644	4·724901	·9783287	3
58	·2073426	·211948	4·718125	·9782684	2
59	·2076272	·212252	4·711368	·9782080	1
60	·2079117	·212556	4·704630	·9781476	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 78.

11 Deg. (11°00′ – 11°30′) — Deg. 78

′	SINE.	TANG.	COTANG.	COSINE.	′
0	·1908090	·194380	5·144554	·9816272	60
1	·1910945	·194682	5·136576	·9815716	59
2	·1913801	·194984	5·128622	·9815160	58
3	·1916656	·195286	5·120692	·9814603	57
4	·1919510	·195588	5·112785	·9814045	56
5	·1922365	·195890	5·104902	·9813486	55
6	·1925220	·196192	5·097042	·9812927	54
7	·1928074	·196494	5·089206	·9812366	53
8	·1930928	·196796	5·081392	·9811805	52
9	·1933782	·197098	5·073602	·9811243	51
10	·1936636	·197400	5·065835	·9810680	50
11	·1939490	·197703	5·058090	·9810116	49
12	·1942344	·198005	5·050369	·9809552	48
13	·1945197	·198307	5·042670	·9808986	47
14	·1948050	·198610	5·034993	·9808420	46
15	·1950903	·198912	5·027339	·9807853	45
16	·1953756	·199214	5·019707	·9807285	44
17	·1956609	·199517	5·012098	·9806716	43
18	·1959461	·199819	5·004511	·9806147	42
19	·1962314	·200122	4·996945	·9805576	41
20	·1965166	·200424	4·989402	·9805005	40
21	·1968018	·200727	4·981881	·9804433	39
22	·1970870	·201030	4·974381	·9803860	38
23	·1973722	·201332	4·966903	·9803286	37
24	·1976573	·201635	4·959447	·9802712	36
25	·1979425	·201938	4·952012	·9802136	35
26	·1982276	·202240	4·944599	·9801560	34
27	·1985127	·202543	4·937206	·9800983	33
28	·1987978	·202845	4·929835	·9800405	32
29	·1990829	·203149	4·922485	·9799827	31
30	·1993679	·203452	4·915157	·9799247	30
′	COSINE.	TANG.	COTANG.	SINE.	′

Deg. 78.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

12 Deg.

'	SINE.	TANG.	COTANG.	COSINE.
0	.2079117	.212556	4.704630	.9781476
1	.2081962	.212850	4.697910	.9780871
2	.2084807	.213164	4.691208	.9780571
3	.2087652	.213468	4.684524	.9779658
4	.2090497	.213773	4.677859	.9779050
5	.2093341	.214077	4.671212	.9778441
6	.2096186	.214381	4.664583	.9777832
7	.2099030	.214685	4.657972	.9777222
8	.2101874	.214990	4.651378	.9776611
9	.2104718	.215294	4.644803	.9775999
10	.2107561	.215598	4.638245	.9775386
11	.2110405	.215903	4.631705	.9774773
12	.2113248	.216207	4.625183	.9774159
13	.2116091	.216512	4.618678	.9773544
14	.2118934	.216816	4.612190	.9772928
15	.2121777	.217121	4.605720	.9772311
16	.2124619	.217425	4.599268	.9771693
17	.2127462	.217730	4.592832	.9771075
18	.2130304	.218035	4.586414	.9770456
19	.2133146	.218340	4.580012	.9769836
20	.2135988	.218644	4.573628	.9769215
21	.2138829	.218949	4.567261	.9768593
22	.2141671	.219254	4.560911	.9767970
23	.2144512	.219559	4.554577	.9767347
24	.2147353	.219864	4.548260	.9766723
25	.2150194	.220169	4.541960	.9766098
26	.2153035	.220474	4.535677	.9765472
27	.2155876	.220779	4.529410	.9764845
28	.2158716	.221084	4.523160	.9764217
29	.2161556	.221389	4.516926	.9763589
30	.2164396	.221694	4.510708	.9762960
'	COSINE.	COTANG.	TANG.	SINE.

DEG. 77

12 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.2167256	.221999	4.504507	.9762330	60
32	.2170076	.222305	4.498322	.9761699	59
33	.2172915	.222610	4.492153	.9761067	58
34	.2175754	.222915	4.486000	.9760435	57
35	.2178593	.223221	4.479863	.9759802	56
36	.2181432	.223526	4.473742	.9759168	55
37	.2184271	.223831	4.467637	.9758533	54
38	.2187110	.224137	4.461548	.9757897	53
39	.2189948	.224442	4.455475	.9757260	52
40	.2192786	.224748	4.449418	.9756623	51
41	.2195624	.225054	4.443376	.9755985	50
42	.2198462	.225359	4.437350	.9755345	49
43	.2201300	.225665	4.431339	.9754706	48
44	.2204137	.225971	4.425343	.9754065	47
45	.2206974	.226276	4.419364	.9753423	46
46	.2209811	.226582	4.413399	.9752781	45
47	.2212648	.226888	4.407450	.9752138	44
48	.2215485	.227194	4.401516	.9751494	43
49	.2218321	.227500	4.395597	.9750849	42
50	.2221158	.227806	4.389634	.9750203	41
51	.2223994	.228112	4.383805	.9749556	40
52	.2226830	.228418	4.377931	.9748909	39
53	.2229666	.228724	4.372073	.9748261	38
54	.2232501	.229030	4.366229	.9747612	37
55	.2235337	.229336	4.360400	.9746962	36
56	.2238172	.229642	4.354586	.9746311	35
57	.2241007	.229949	4.348786	.9745660	34
58	.2243842	.230255	4.343001	.9745008	33
59	.2246676	.230561	4.337231	.9744355	32
60	.2249511	.230868	4.331475	.9743701	31
'	COSINE.	COTANG.	TANG.	SINE.	'

DEG. 77.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

13 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
0	.2249511	.230868	4.331475	.9743701	60
1	.2252345	.231174	4.325734	.9743046	59
2	.2255179	.231481	4.320007	.9742390	58
3	.2258013	.231787	4.314295	.9741734	57
4	.2260846	.232094	4.308597	.9741077	56
5	.2263680	.232400	4.302913	.9740419	55
6	.2266513	.232707	4.297244	.9739760	54
7	.2269346	.233014	4.291588	.9739100	53
8	.2272179	.233320	4.285947	.9738439	52
9	.2275012	.233627	4.280319	.9737778	51
10	.2277844	.233934	4.274706	.9737116	50
11	.2280677	.234241	4.269107	.9736453	49
12	.2283509	.234547	4.263521	.9735789	48
13	.2286341	.234854	4.257950	.9735124	47
14	.2289172	.235161	4.252392	.9734458	46
15	.2292004	.235468	4.246848	.9733792	45
16	.2294835	.235775	4.241317	.9733125	44
17	.2297666	.236082	4.235800	.9732457	43
18	.2300497	.236390	4.230297	.9731789	42
19	.2303328	.236697	4.224808	.9731119	41
20	.2306159	.237004	4.219331	.9730449	40
21	.2308989	.237311	4.213869	.9729777	39
22	.2311819	.237618	4.208419	.9729105	38
23	.2314649	.237926	4.202983	.9728432	37
24	.2317479	.238233	4.197560	.9727759	36
25	.2320309	.238541	4.192151	.9727084	35
26	.2323138	.238848	4.186754	.9726409	34
27	.2325967	.239156	4.181371	.9725733	33
28	.2328796	.239463	4.176001	.9725056	32
29	.2331625	.239771	4.170644	.9724378	31
30	.2334454	.240078	4.165299	.9723699	30
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 76.

13 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.2337282	.240386	4.159968	.9723020	29
32	.2340110	.240694	4.154650	.9722339	28
33	.2342938	.241001	4.149344	.9721658	27
34	.2345766	.241309	4.144051	.9720976	26
35	.2348594	.241617	4.138771	.9720294	25
36	.2351421	.241925	4.133504	.9719610	24
37	.2354248	.242233	4.128249	.9718926	23
38	.2357075	.242541	4.123007	.9718240	22
39	.2359902	.242849	4.117778	.9717554	21
40	.2362729	.243157	4.112561	.9716867	20
41	.2365555	.243465	4.107356	.9716180	19
42	.2368381	.243773	4.102164	.9715491	18
43	.2371207	.244081	4.096985	.9714802	17
44	.2374033	.244390	4.091817	.9714112	16
45	.2376859	.244698	4.086662	.9713421	15
46	.2379684	.245006	4.081519	.9712729	14
47	.2382510	.245315	4.076389	.9712036	13
48	.2385335	.245623	4.071270	.9711343	12
49	.2388159	.245932	4.066164	.9710649	11
50	.2390984	.246240	4.061070	.9709953	10
51	.2393808	.246549	4.055987	.9709258	9
52	.2396633	.246857	4.050917	.9708561	8
53	.2399457	.247166	4.045859	.9707863	7
54	.2402280	.247475	4.040812	.9707165	6
55	.2405104	.247783	4.035777	.9706466	5
56	.2407927	.248092	4.030755	.9705766	4
57	.2410751	.248401	4.025744	.9705065	3
58	.2413574	.248710	4.020744	.9704363	2
59	.2416396	.249019	4.015757	.9703660	1
60	.2419219	.249328	4.010780	.9702957	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 76.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

14 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	2419219	249328	4010780	9702957	60
1	2422041	249637	4005816	9702253	59
2	2424863	249946	4000863	9701548	58
3	2427685	250255	3995922	9700842	57
4	2430507	250564	3990992	9700135	56
5	2433329	250873	3986073	9699428	55
6	2436150	251183	3981166	9698720	54
7	2438971	251491	3976271	9698011	53
8	2441792	251801	3971386	9697301	52
9	2444613	252110	3966513	9696591	51
10	2447433	252420	3961651	9695879	50
11	2450254	252729	3956801	9695167	49
12	2453074	253038	3951961	9694453	48
13	2455894	253348	3947133	9693740	47
14	2458713	253658	3942315	9693025	46
15	2461533	253967	3937509	9692309	45
16	2464352	254277	3932714	9691593	44
17	2467171	254587	3927929	9690875	43
18	2469990	254896	3923156	9690157	42
19	2472809	255206	3918393	9689438	41
20	2475627	255516	3913642	9688719	40
21	2478445	255826	3908901	9687998	39
22	2481263	256136	3904171	9687277	38
23	2484081	256446	3899451	9686555	37
24	2486899	256756	3894742	9685832	36
25	2489716	257066	3890044	9685108	35
26	2492533	257376	3885357	9684383	34
27	2495350	257686	3880680	9683658	33
28	2498167	257997	3876014	9682931	32
29	2500984	258307	3871358	9682204	31
30	2503800	258617	3866713	9681476	30
COSINE.		**COTANG.**	**TANG.**	**SINE.**	'

DEG. 76.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	2506616	258928	3862078	9680748	29
32	2509432	259238	3857453	9680018	28
33	2512248	259548	3852839	9679298	27
34	2515063	259859	3848235	9678567	26
35	2517879	260169	3843642	9677825	25
36	2520694	260480	3839059	9677092	24
37	2523508	260791	3834486	9676358	23
38	2526323	261101	3829923	9675624	22
39	2529137	261412	3825370	9674888	21
40	2531952	261723	3820828	9674152	20
41	2534766	262034	3816295	9673415	19
42	2537579	262345	3811773	9672678	18
43	2540393	262656	3807260	9671939	17
44	2543206	262967	3802758	9671200	16
45	2546019	263278	3798266	9670459	15
46	2548832	263589	3793783	9669718	14
47	2551645	263900	3789310	9668977	13
48	2554458	264211	3784848	9668234	12
49	2557270	264522	3780395	9667490	11
50	2560082	264833	3775951	9666746	10
51	2562894	265145	3771518	9666001	9
52	2565705	265456	3767094	9665255	8
53	2568517	265768	3762680	9664508	7
54	2571328	266079	3758276	9663761	6
55	2574139	266390	3753881	9663012	5
56	2576950	266702	3749496	9662263	4
57	2579760	267014	3745120	9661513	3
58	2582570	267325	3740754	9660762	2
59	2585381	267637	3736398	9660011	1
60	2588190	267949	3732050	9659258	0
COSINE.		**COTANG.**	**TANG.**	**SINE.**	'

DEG. 75.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

15 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.2588190	.267949	3.732050	.9659258	60
1	.2591000	.268261	3.727713	.9658505	59
2	.2593810	.268572	3.723384	.9657751	58
3	.2596619	.268884	3.719065	.9656996	57
4	.2599428	.269196	3.714756	.9656240	56
5	.2602237	.269508	3.710455	.9655484	55
6	.2605045	.269820	3.706164	.9654726	54
7	.2607853	.270132	3.701883	.9653968	53
8	.2610662	.270444	3.697610	.9653209	52
9	.2613469	.270757	3.693346	.9652449	51
10	.2616277	.271069	3.689092	.9651689	50
11	.2619085	.271381	3.684847	.9650927	49
12	.2621892	.271694	3.680611	.9650165	48
13	.2624699	.272006	3.676384	.9649402	47
14	.2627506	.272318	3.672166	.9648638	46
15	.2630312	.272631	3.667957	.9647873	45
16	.2633118	.272943	3.663757	.9647108	44
17	.2635925	.273256	3.659566	.9646341	43
18	.2638730	.273569	3.655384	.9645574	42
19	.2641536	.273881	3.651211	.9644806	41
20	.2644342	.274194	3.647046	.9644037	40
21	.2647147	.274507	3.642891	.9643268	39
22	.2649952	.274820	3.638744	.9642497	38
23	.2652757	.275133	3.634606	.9641726	37
24	.2655561	.275445	3.630477	.9640954	36
25	.2658366	.275758	3.626356	.9640181	35
26	.2661170	.276071	3.622244	.9639407	34
27	.2663973	.276385	3.618141	.9638633	33
28	.2666777	.276698	3.614046	.9637858	32
29	.2669581	.277011	3.609960	.9637081	31
30	.2672384	.277324	3.605883	.9636303	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 74.

15 Deg

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.2675187	.277637	3.601814	.9635527	29
32	.2677989	.277951	3.597754	.9634748	28
33	.2680792	.278264	3.593702	.9633969	27
34	.2683594	.278578	3.589659	.9633189	26
35	.2686396	.278891	3.585624	.9632408	25
36	.2689198	.279205	3.581597	.9631626	24
37	.2692000	.279518	3.577579	.9630843	23
38	.2694801	.279832	3.573569	.9630060	22
39	.2697602	.280145	3.569568	.9629275	21
40	.2700403	.280459	3.565574	.9628490	20
41	.2703204	.280773	3.561590	.9627704	19
42	.2706004	.281087	3.557613	.9626917	18
43	.2708805	.281401	3.553644	.9626130	17
44	.2711605	.281715	3.549684	.9625342	16
45	.2714404	.282029	3.545732	.9624552	15
46	.2717204	.282343	3.541788	.9623762	14
47	.2720002	.282657	3.537852	.9622972	13
48	.2722802	.282971	3.533925	.9622180	12
49	.2725601	.283285	3.530005	.9621387	11
50	.2728400	.283599	3.526093	.9620594	10
51	.2731198	.283914	3.522190	.9619800	9
52	.2733997	.284228	3.518294	.9619005	8
53	.2736794	.284543	3.514407	.9618210	7
54	.2739592	.284857	3.510527	.9617413	6
55	.2742390	.285172	3.506655	.9616616	5
56	.2745187	.285486	3.502791	.9615818	4
57	.2747984	.285801	3.498935	.9615019	3
58	.2750781	.286115	3.495087	.9614219	2
59	.2753577	.286430	3.491247	.9613418	1
60	.2756374	.286745	3.487414	.9612617	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 74.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

16 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.2756374	.286745	3.487414	.9612617	60
1	.2759170	.287060	3.483589	.9611815	59
2	.2761965	.287375	3.479772	.9611012	58
3	.2764761	.287690	3.475963	.9610208	57
4	.2767556	.288005	3.472161	.9609403	56
5	.2770352	.288320	3.468367	.9608598	55
6	.2773147	.288635	3.464581	.9607792	54
7	.2775941	.288950	3.460802	.9606984	53
8	.2778736	.289265	3.457031	.9606177	52
9	.2781530	.289580	3.453267	.9605368	51
10	.2784324	.289896	3.449512	.9604558	50
11	.2787118	.290211	3.445763	.9603748	49
12	.2789911	.290526	3.442022	.9602937	48
13	.2792704	.290842	3.438289	.9602125	47
14	.2795497	.291157	3.434563	.9601312	46
15	.2798290	.291473	3.430844	.9600499	45
16	.2801083	.291789	3.427133	.9599684	44
17	.2803875	.292104	3.423429	.9598869	43
18	.2806667	.292420	3.419733	.9598053	42
19	.2809459	.292736	3.416044	.9597236	41
20	.2812251	.293052	3.412362	.9596418	40
21	.2815042	.293368	3.408688	.9595600	39
22	.2817833	.293683	3.405021	.9594781	38
23	.2820624	.293999	3.401361	.9593961	37
24	.2823415	.294316	3.397708	.9593141	36
25	.2826205	.294632	3.394063	.9592318	35
26	.2828995	.294948	3.390424	.9591496	34
27	.2831785	.295264	3.386793	.9590672	33
28	.2834575	.295580	3.383169	.9589848	32
29	.2837364	.295897	3.379553	.9589023	31
30	.2840153	.296213	3.375943	.9588197	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 73.

16 Deg.

'	COSINE.	COTANG.	TANG.	SINE.	'
31	.9587371	3.372340	.296529	.2842942	29
32	.9586545	3.368745	.296846	.2845731	28
33	.9585715	3.365156	.297163	.2848520	27
34	.9584896	3.361575	.297479	.2851308	26
35	.9584056	3.358000	.297796	.2854096	25
36	.9583226	3.354433	.298112	.2856884	24
37	.9582394	3.350872	.298429	.2859671	23
38	.9581562	3.347319	.298746	.2862458	22
39	.9580729	3.343772	.299063	.2865246	21
40	.9579995	3.340232	.299380	.2868032	20
41	.9579060	3.336699	.299697	.2870819	19
42	.9578225	3.333173	.300014	.2873605	18
43	.9577389	3.329654	.300331	.2876391	17
44	.9576552	3.326141	.300648	.2879163	16
45	.9575714	3.322636	.300965	.2881963	15
46	.9574875	3.319137	.301283	.2884748	14
47	.9574035	3.315645	.301600	.2887533	13
48	.9573196	3.312159	.301917	.2890318	12
49	.9572354	3.308681	.302235	.2893103	11
50	.9571512	3.305209	.302552	.2895887	10
51	.9570669	3.301743	.302870	.2898671	9
52	.9569825	3.298285	.303187	.2901455	8
53	.9568981	3.294833	.303505	.2904239	7
54	.9568136	3.291387	.303823	.2907022	6
55	.9567290	3.287948	.304141	.2909805	5
56	.9566443	3.284516	.304458	.2912588	4
57	.9565596	3.281090	.304776	.2915371	3
58	.9564747	3.277671	.305094	.2918153	2
59	.9563898	3.274258	.305412	.2920935	1
60	.9563048	3.270852	.305730	.2923717	0
'	SINE.	TANG.	COTANG.	COSINE.	'

Deg. 73.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

17 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·2923717	·305730	3·270852	·9563048	60
1	·2926499	·306048	3·267432	·9562197	59
2	·2929280	·306367	3·264059	·9561345	58
3	·2932061	·306685	3·260672	·9560492	57
4	·2934842	·307003	3·257292	·9559639	56
5	·2937623	·307321	3·253918	·9558785	55
6	·2940403	·307640	3·250550	·9557930	54
7	·2943183	·307958	3·247189	·9557074	53
8	·2945963	·308277	3·243834	·9556218	52
9	·2948743	·308595	3·240486	·9555361	51
10	·2951522	·308914	3·237143	·9554502	50
11	·2954302	·309233	3·233807	·9553643	49
12	·2957081	·309551	3·230478	·9552784	48
13	·2959859	·309870	3·227154	·9551923	47
14	·2962638	·310189	3·223837	·9551062	46
15	·2965416	·310508	3·220526	·9550199	45
16	·2968194	·310827	3·217221	·9549336	44
17	·2970971	·311146	3·213922	·9548473	43
18	·2973749	·311465	3·210630	·9547608	42
19	·2976526	·311784	3·207344	·9546743	41
20	·2979303	·312103	3·204063	·9545876	40
21	·2982079	·312422	3·200789	·9545009	39
22	·2984856	·312742	3·197521	·9544141	38
23	·2987632	·313061	3·194259	·9543273	37
24	·2990408	·313381	3·191003	·9542403	36
25	·2993184	·313700	3·187754	·9541533	35
26	·2995959	·314020	3·184510	·9540662	34
27	·2998734	·314339	3·181272	·9539790	33
28	·3001509	·314659	3·178040	·9538917	32
29	·3004284	·314979	3·174814	·9538044	31
30	·3007058	·315298	3·171594	·9537170	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 72.

17 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·3009832	·315618	3·168800	·9536294	29
32	·3012606	·315938	3·165172	·9535418	28
33	·3015380	·316258	3·161970	·9534542	27
34	·3018153	·316578	3·158774	·9533664	26
35	·3020926	·316898	3·155584	·9532786	25
36	·3023699	·317218	3·152399	·9531907	24
37	·3026471	·317538	3·149220	·9531027	23
38	·3029244	·317859	3·146047	·9530146	22
39	·3032016	·318179	3·142880	·9529264	21
40	·3034788	·318499	3·139719	·9528382	20
41	·3037559	·318820	3·136563	·9527499	19
42	·3040331	·319140	3·133414	·9526615	18
43	·3043102	·319461	3·130270	·9525730	17
44	·3045872	·319781	3·127131	·9524844	16
45	·3048643	·320102	3·123999	·9523958	15
46	·3051413	·320423	3·120872	·9523071	14
47	·3054183	·320743	3·117750	·9522183	13
48	·3056953	·321064	3·114635	·9521294	12
49	·3059723	·321385	3·111525	·9520404	11
50	·3062492	·321706	3·108421	·9519514	10
51	·3065261	·322027	3·105322	·9518623	9
52	·3068030	·322348	3·102229	·9517731	8
53	·3070798	·322670	3·099141	·9516838	7
54	·3073566	·322991	3·096059	·9515944	6
55	·3076334	·323312	3·092982	·9515050	5
56	·3079102	·323633	3·089912	·9514154	4
57	·3081869	·323955	3·086846	·9513258	3
58	·3084636	·324276	3·083786	·9512361	2
59	·3087403	·324598	3·080732	·9511464	1
60	·3090170	·324919	3·077683	·9510565	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 72.

8

THE RAILROAD ENGINEER'S

NATURAL SINES AND TANGENTS TO A RADIUS 1.

18 Deg.

′	SINE	TANG.	COTANG.	COSINE	′
0	3090170	324919	3.077683	9510565	60
1	3092896	325241	3.074940	9509666	59
2	3095702	325563	3.071602	9508766	58
3	3098468	325884	3.068569	9507865	57
4	3101234	326206	3.065542	9506963	56
5	3103999	326528	3.062520	9506061	55
6	3106764	326850	3.059503	9505167	54
7	3109529	327172	3.056492	9504253	53
8	3112294	327494	3.053487	9503348	52
9	3115058	327816	3.050486	9502443	51
10	3117822	328138	3.047491	9501536	50
11	3120586	328461	3.044501	9500629	49
12	3123349	328783	3.041517	9499721	48
13	3126112	329105	3.038538	9498812	47
14	3128875	329428	3.035564	9497902	46
15	3131638	329750	3.032595	9496991	45
16	3134400	330073	3.029632	9496080	44
17	3137163	330395	3.026673	9495168	43
18	3139925	330718	3.023720	9494255	42
19	3142686	331041	3.020772	9493341	41
20	3145448	331363	3.017830	9492426	40
21	3148209	331686	3.014892	9491511	39
22	3150969	332009	3.011960	9490595	38
23	3153730	332332	3.009033	9489678	37
24	3156490	332655	3.006110	9488760	36
25	3159250	332978	3.003193	9487842	35
26	3162010	333302	3.000282	9486922	34
27	3164770	333625	2.997375	9486002	33
28	3167529	333948	2.994473	9485081	32
29	3170288	334271	2.991576	9484159	31
30	3173047	334595	2.988685	9483237	30
′	COSINE	TANG.	COTANG.	SINE	′

Deg. 71.

′	SINE	TANG.	COTANG.	COSINE	′
31	3175805	334918	2.985798	9482313	29
32	3178563	335242	2.982916	9481389	28
33	3181321	335566	2.980040	9480464	27
34	3184079	335889	2.977168	9479538	26
35	3186836	336213	2.974301	9478612	25
36	3189593	336537	2.971439	9477684	24
37	3192350	336861	2.968583	9476756	23
38	3195106	337185	2.965731	9475827	22
39	3197863	337509	2.962884	9474897	21
40	3200619	337833	2.960042	9473966	20
41	3203374	338157	2.957205	9473035	19
42	3206130	338481	2.954372	9472103	18
43	3208885	338805	2.951545	9471170	17
44	3211640	339129	2.948722	9470236	16
45	3214395	339454	2.945905	9469301	15
46	3217149	339778	2.943092	9468366	14
47	3219903	340103	2.940284	9467430	13
48	3222657	340427	2.937480	9466493	12
49	3225411	340752	2.934682	9465555	11
50	3228164	341077	2.931888	9464616	10
51	3230917	341402	2.929099	9463677	9
52	3233670	341726	2.926315	9462736	8
53	3236422	342051	2.923535	9461795	7
54	3239174	342376	2.920761	9460854	6
55	3241926	342701	2.917990	9459911	5
56	3244678	343026	2.915225	9458968	4
57	3247429	343352	2.912464	9458023	3
58	3250180	343677	2.909708	9457078	2
59	3252931	344002	2.906957	9456132	1
60	3255682	344327	2.904210	9455186	0
′	COSINE	COTANG.	TANG.	SINE	′

18 Deg.

Deg. 71.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

19 Deg.

'	SINE	TANG	COTANG	COSINE	'
31	3348010	354446	2821304	9425444	29
32	3345552	354773	2818700	9424471	28
33	3340293	355101	2816100	9423498	27
34	3340934	355428	2813504	9422525	26
35	3351775	355756	2810913	9421550	25
36	3354516	356084	2808326	9420575	24
37	3357256	356411	2805743	9419598	23
38	3359996	356739	2803164	9418621	22
39	3362735	357067	2800590	9417644	21
40	3365475	357395	2798019	9416665	20
41	3368214	357723	2795453	9415686	19
42	3370953	358051	2792891	9414705	18
43	3373691	358380	2790333	9413724	17
44	3376429	358708	2787779	9412743	16
45	3379167	359036	2785230	9411760	15
46	3381905	359365	2782685	9410777	14
47	3384642	359693	2780144	9409793	13
48	3387379	360022	2777605	9408808	12
49	3390116	360350	2775073	9407822	11
50	3392852	360679	2772544	9406835	10
51	3395589	361008	2770019	9405848	9
52	3398325	361337	2767499	9404860	8
53	3401060	361666	2764982	9403871	7
54	3403796	361994	2762469	9402881	6
55	3406531	362324	2759960	9401891	5
56	3409265	362653	2757456	9400899	4
57	3412000	362982	2754955	9399907	3
58	3414734	363311	2752458	9398914	2
59	3417468	363640	2749966	9397921	1
60	3420201	363970	2747477	9396926	0
'	COSINE	COTANG	TANG	SINE	'

DEG. 70.

19 Deg.

'	SINE	TANG	COTANG	COSINE	'
0	3255682	344327	2904210	9455186	60
1	3258432	344653	2901468	9454238	59
2	3261182	344978	2898731	9453290	58
3	3263932	345304	2895998	9452341	57
4	3266681	345629	2893270	9451391	56
5	3269430	345955	2890546	9450441	55
6	3272179	346281	2887827	9449489	54
7	3274928	346606	2885113	9448537	53
8	3277676	346932	2882403	9447584	52
9	3280424	347258	2879697	9446630	51
10	3283172	347584	2876997	9445675	50
11	3285919	347910	2874300	9444720	49
12	3288666	348236	2871608	9443764	48
13	3291413	348563	2868921	9442807	47
14	3294160	348889	2866238	9441849	46
15	3296906	349215	2863560	9440890	45
16	3299653	349542	2860886	9439931	44
17	3302398	349868	2858216	9438971	43
18	3305144	350195	2855551	9438010	42
19	3307889	350521	2852891	9437048	41
20	3310634	350848	2850234	9436085	40
21	3313379	351175	2847583	9435122	39
22	3316123	351501	2844935	9434157	38
23	3318867	351828	2842292	9433192	37
24	3321611	352155	2839653	9432227	36
25	3324355	352482	2837019	9431260	35
26	3327098	352809	2834389	9430293	34
27	3329841	353136	2831763	9429324	33
28	3332584	353464	2829142	9428355	32
29	3335326	353791	2826525	9427386	31
30	3338069	354118	2823912	9426415	30
'	COSINE	TANG	COTANG	SINE	'

DEG. 70.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

20 DEG.

′	SINE	TANG.	COTANG.	COSINE	′
0	.3420201	.363970	2.747477	.9396926	60
1	.3422835	.364299	2.744992	.9395631	59
2	.3425568	.364629	2.742512	.9394635	58
3	.3428400	.364958	2.740035	.9393938	57
4	.3431133	.365288	2.737562	.9392940	56
5	.3433865	.365618	2.735093	.9391942	55
6	.3436597	.365948	2.732628	.9390943	54
7	.3439329	.366277	2.730167	.9389943	53
8	.3442060	.366607	2.727719	.9388942	52
9	.3444791	.366937	2.725256	.9387940	51
10	.3447521	.367268	2.722807	.9386938	50
11	.3450252	.367598	2.720362	.9385934	49
12	.3452982	.367928	2.717920	.9384930	48
13	.3455712	.368258	2.715482	.9383925	47
14	.3458441	.368589	2.713048	.9382920	46
15	.3461171	.368919	2.710618	.9381913	45
16	.3463900	.369250	2.708192	.9380906	44
17	.3466628	.369580	2.705769	.9379898	43
18	.3469357	.369911	2.703351	.9378889	42
19	.3472085	.370242	2.700936	.9377880	41
20	.3474812	.370573	2.698525	.9376869	40
21	.3477540	.370903	2.696118	.9375858	39
22	.3480267	.371234	2.693714	.9374846	38
23	.3482994	.371565	2.691314	.9373833	37
24	.3485720	.371896	2.688919	.9372820	36
25	.3488447	.372227	2.686526	.9371806	35
26	.3491173	.372559	2.684138	.9370790	34
27	.3493898	.372890	2.681753	.9369774	33
28	.3496624	.373221	2.679372	.9368758	32
29	.3499349	.373553	2.676995	.9367742	31
30	.3502074	.373884	2.674621	.9366722	30
′	COSINE	COTANG.	TANG.	SINE	′

DEG. 69.

20 DEG.

′	SINE	TANG.	COTANG.	COSINE	′
31	.3504798	.374216	2.672251	.9365703	29
32	.3507523	.374547	2.669885	.9364683	28
33	.3510246	.374879	2.667522	.9363662	27
34	.3512970	.375211	2.665163	.9362641	26
35	.3515693	.375543	2.662808	.9361618	25
36	.3518416	.375875	2.660456	.9360595	24
37	.3521139	.376207	2.658108	.9359571	23
38	.3523862	.376539	2.655764	.9358547	22
39	.3526584	.376871	2.653423	.9357521	21
40	.3529306	.377203	2.651096	.9356495	20
41	.3532027	.377536	2.648763	.9355468	19
42	.3534748	.377868	2.646423	.9354440	18
43	.3537469	.378201	2.644096	.9353412	17
44	.3540190	.378533	2.641774	.9352382	16
45	.3542910	.378866	2.639454	.9351352	15
46	.3545630	.379198	2.637139	.9350321	14
47	.3548350	.379531	2.634827	.9349289	13
48	.3551070	.379864	2.632518	.9348257	12
49	.3553789	.380197	2.630213	.9347223	11
50	.3556508	.380530	2.627912	.9346189	10
51	.3559226	.380863	2.625614	.9345154	9
52	.3561944	.381196	2.623319	.9344119	8
53	.3564662	.381529	2.621028	.9343082	7
54	.3567380	.381862	2.618741	.9342045	6
55	.3570097	.382196	2.616457	.9341007	5
56	.3572814	.382529	2.614176	.9339968	4
57	.3575531	.382863	2.611899	.9338928	3
58	.3578248	.383196	2.609625	.9337888	2
59	.3580964	.383530	2.607355	.9336846	1
60	.3583679	.383864	2.605089	.9335804	0
′	COSINE	COTANG.	TANG.	SINE	′

DEG. 69.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

21 Deg.

′	SINE	TANG.	COTANG.	COSINE	′
31	·3667719	·394246	2·536483	·9303109	29
32	·3670425	·394582	2·534323	·9302042	28
33	·3673130	·394918	2·532165	·9300974	27
34	·3675836	·395255	2·530011	·9299905	26
35	·3678541	·395591	2·527859	·9298835	25
36	·3681246	·395928	2·525711	·9297765	24
37	·3683950	·396264	2·523566	·9296694	23
38	·3686654	·396601	2·521424	·9295622	22
39	·3689358	·396937	2·519286	·9294549	21
40	·3692061	·397274	2·517150	·9293475	20
41	·3694765	·397611	2·515018	·9292401	19
42	·3697468	·397948	2·512889	·9291326	18
43	·3700170	·398285	2·510762	·9290250	17
44	·3702872	·398622	2·508639	·9289173	16
45	·3705674	·398959	2·506519	·9288096	15
46	·3708276	·399296	2·504402	·9287017	14
47	·3710977	·399634	2·502289	·9285938	13
48	·3713678	·399971	2·500178	·9284858	12
49	·3716379	·400308	2·498070	·9283778	11
50	·3719079	·400646	2·495966	·9282696	10
51	·3721780	·400984	2·493864	·9281614	9
52	·3724479	·401321	2·491766	·9280531	8
53	·3727179	·401659	2·489670	·9279447	7
54	·3729878	·401997	2·487578	·9278363	6
55	·3732577	·402335	2·485488	·9277277	5
56	·3735275	·402673	2·483402	·9276191	4
57	·3737973	·403011	2·481319	·9275104	3
58	·3740671	·403349	2·479238	·9274016	2
59	·3743369	·403687	2·477161	·9272928	1
60	·3746066	·404026	2·475086	·9271839	0
′	COSINE	COTANG.	TANG.	SINE	′

Deg. 68.

21 Deg.

′	SINE	TANG.	COTANG.	COSINE	′
0	·3583679	·383864	2·605089	·9335904	60
1	·3586395	·384197	2·602825	·9334761	59
2	·3589110	·384531	2·600565	·9333718	58
3	·3591825	·384865	2·598309	·9332673	57
4	·3594540	·385199	2·596056	·9331628	56
5	·3597254	·385533	2·593806	·9330582	55
6	·3599968	·385867	2·591560	·9329535	54
7	·3602682	·386202	2·589317	·9328488	53
8	·3605395	·386536	2·587078	·9327439	52
9	·3608102	·386870	2·584842	·9326390	51
10	·3610821	·387205	2·582609	·9325340	50
11	·3613534	·387539	2·580380	·9324289	49
12	·3616246	·387874	2·578153	·9323238	48
13	·3618958	·388209	2·575931	·9322186	47
14	·3621669	·388543	2·573711	·9321133	46
15	·3624380	·388878	2·571495	·9320079	45
16	·3627091	·389213	2·569283	·9319024	44
17	·3629802	·389548	2·567073	·9317969	43
18	·3632512	·389883	2·564867	·9316912	42
19	·3635222	·390218	2·562664	·9315855	41
20	·3637932	·390554	2·560464	·9314797	40
21	·3640641	·390889	2·558268	·9313739	39
22	·3643351	·391224	2·556075	·9312679	38
23	·3646059	·391560	2·553885	·9311619	37
24	·3648768	·391895	2·551699	·9310558	36
25	·3651476	·392231	2·549516	·9309496	35
26	·3654184	·392567	2·547335	·9308434	34
27	·3656891	·392902	2·545159	·9307370	33
28	·3659599	·393238	2·542985	·9306306	32
29	·3662306	·393574	2·540815	·9305241	31
30	·3665012	·393910	2·538647	·9304176	30
′	COSINE	TANG.	COTANG.	SINE	′

Deg. 68.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

22 Deg.

′	SINE.	COTANG.	TANG.	COSINE.	′
0	.3746066	2.475086	.404026	.9271839	60
1	.3748763	2.473015	.404364	.9270748	59
2	.3751459	2.470947	.404703	.9269658	58
3	.3754156	2.468881	.405041	.9268566	57
4	.3756852	2.466819	.405380	.9267474	56
5	.3759547	2.464759	.405718	.9266380	55
6	.3762243	2.462703	.406057	.9265286	54
7	.3764938	2.460649	.406396	.9264192	53
8	.3767632	2.458598	.406735	.9263096	52
9	.3770327	2.456551	.407074	.9262000	51
10	.3773021	2.454506	.407413	.9260902	50
11	.3775714	2.452464	.407753	.9259805	49
12	.3778408	2.450425	.408092	.9258706	48
13	.3781101	2.448389	.408431	.9257606	47
14	.3783794	2.446355	.408771	.9256506	46
15	.3786486	2.444325	.409110	.9255405	45
16	.3789178	2.442298	.409450	.9254303	44
17	.3791870	2.440273	.409790	.9253201	43
18	.3794562	2.438251	.410129	.9252097	42
19	.3797253	2.436233	.410469	.9250993	41
20	.3799944	2.434217	.410809	.9249888	40
21	.3802634	2.432204	.411149	.9248782	39
22	.3805324	2.430193	.411489	.9247676	38
23	.3808014	2.428186	.411830	.9246568	37
24	.3810704	2.426181	.412170	.9245460	36
25	.3813393	2.424180	.412510	.9244351	35
26	.3816082	2.422181	.412851	.9243242	34
27	.3818770	2.420185	.413191	.9242131	33
28	.3821459	2.418191	.413532	.9241020	32
29	.3824147	2.416201	.413872	.9239908	31
30	.3826834	2.414213	.414213	.9238795	30
′	COSINE.	TANG.	COTANG.	SINE.	′

Deg. 67.

22 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.3829522	.414554	2.412228	.9237682	29
32	.3832209	.414895	2.410246	.9236567	28
33	.3834895	.415236	2.408267	.9235452	27
34	.3837582	.415577	2.406290	.9234336	26
35	.3840268	.415918	2.404316	.9233220	25
36	.3842953	.416259	2.402345	.9232102	24
37	.3845639	.416601	2.400377	.9230984	23
38	.3848324	.416942	2.398411	.9229865	22
39	.3851008	.417284	2.396449	.9228745	21
40	.3853693	.417625	2.394488	.9227624	20
41	.3856377	.417967	2.392531	.9226503	19
42	.3859060	.418309	2.390576	.9225381	18
43	.3861744	.418650	2.388625	.9224258	17
44	.3864427	.418992	2.386675	.9223134	16
45	.3867110	.419334	2.384729	.9222010	15
46	.3869792	.419676	2.382785	.9220884	14
47	.3872474	.420019	2.380844	.9219758	13
48	.3875156	.420361	2.378906	.9218632	12
49	.3877837	.420703	2.376970	.9217504	11
50	.3880519	.421046	2.375037	.9216375	10
51	.3883199	.421388	2.373106	.9215246	9
52	.3885880	.421731	2.371179	.9214116	8
53	.3888560	.422073	2.369254	.9212986	7
54	.3891240	.422416	2.367331	.9211854	6
55	.3893919	.422759	2.365411	.9210722	5
56	.3896598	.423102	2.363494	.9209589	4
57	.3899277	.423445	2.361580	.9208455	3
58	.3901955	.423788	2.359668	.9207320	2
59	.3904633	.424131	2.357759	.9206185	1
60	.3907311	.424474	2.355852	.9205049	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 67.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

23 DEG

'	COSINE.	COTANG.	TANG.	SINE.	'
31	·9169440	2·299014	·435158	·3990158	29
32	·9168279	2·296188	·435504	·3992·25	28
33	·9167118	2·294365	·435850	·3995492	27
34	·9165935	2·292544	·436196	·3998158	26
35	·9164791	2·290725	·436542	·4000825	25
36	·9163627	2·288909	·436889	·4003490	24
37	·9162462	2·287095	·437235	·4006156	23
38	·9161297	2·285284	·437582	·4008821	22
39	·9160130	2·283475	·437928	·4011486	21
40	·9158963	2·281669	·438275	·4014150	20
41	·9157795	2·279865	·438622	·4016814	19
42	·9156626	2·278063	·438969	·4019478	18
43	·9155456	2·276264	·439316	·4022141	17
44	·9154296	2·274467	·439663	·4024804	16
45	·9153115	2·272672	·440010	·4027467	15
46	·9151943	2·270880	·440357	·4030129	14
47	·9150770	2·269090	·440705	·4032791	13
48	·9149597	2·267303	·441052	·4035453	12
49	·9148422	2·265518	·441400	·4038114	11
50	·9147247	2·263735	·441747	·4040775	10
51	·9146072	2·261955	·442095	·4043436	9
52	·9144895	2·260177	·442443	·4046096	8
53	·9143718	2·258401	·442791	·4048756	7
54	·9142540	2·256628	·443139	·4051416	6
55	·9141361	2·254857	·443487	·4054075	5
56	·9140181	2·253088	·443835	·4056734	4
57	·9139001	2·251322	·444183	·4059393	3
58	·9137819	2·249558	·444531	·4062051	2
59	·9136637	2·247796	·444880	·4064709	1
60	·9135455	2·246036	·445228	·4067366	0
'	SINE.	COTANG.	TANG.	COSINE.	'

DEG. 66

23 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·3907311	·424474	2·355852	·9205049	60
1	·3909969	·424818	2·353948	·9203912	59
2	·3912630	·425161	2·352046	·9202774	58
3	·3915343	·425505	2·350148	·9201635	57
4	·3918019	·425848	2·348251	·9200496	56
5	·3920695	·426192	2·346358	·9199356	55
6	·3923371	·426536	2·344467	·9198215	54
7	·3926047	·426880	2·342578	·9197073	53
8	·3928722	·427223	2·340692	·9195931	52
9	·3931397	·427568	2·338809	·9194788	51
10	·3934071	·427912	2·336928	·9193644	50
11	·3936745	·428256	2·335050	·9192499	49
12	·3939419	·428600	2·333174	·9191353	48
13	·3942093	·428944	2·331301	·9190207	47
14	·3944765	·429289	2·329431	·9189060	46
15	·3947439	·429633	2·327563	·9187912	45
16	·3950111	·429978	2·325697	·9186763	44
17	·3952783	·430323	2·323834	·9185614	43
18	·3955455	·430668	2·321974	·9184464	42
19	·3958127	·431012	2·320116	·9183313	41
20	·3960798	·431357	2·318260	·9182161	40
21	·3963468	·431702	2·316407	·9181009	39
22	·3966139	·432048	2·314557	·9179855	38
23	·3968809	·432393	2·312709	·9178701	37
24	·3971479	·432738	2·310863	·9177546	36
25	·3974148	·433084	2·309020	·9176391	35
26	·3976818	·433429	2·307180	·9175234	34
27	·3979486	·433775	2·305342	·9174077	33
28	·3982155	·434120	2·303506	·9172919	32
29	·3984823	·434466	2·301673	·9171760	31
30	·3987491	·434812	2·299842	·9170601	30
'	COSINE.	COTANG.	TANG.	SINE.	'

DEG. 66.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

24 Deg.   **Deg. 65.**

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·4067366	·445228	2·246036	·9135455	60
1	·4070024	·445577	2·244279	·9134271	59
2	·4072681	·445926	2·242524	·9133087	58
3	·4075337	·446274	2·240772	·9131902	57
4	·4077993	·446623	2·239021	·9130716	56
5	·4080649	·446972	2·237273	·9129529	55
6	·4083305	·447321	2·235528	·9128342	54
7	·4085960	·447670	2·233784	·9127154	53
8	·4088615	·448020	2·232043	·9125965	52
9	·4091269	·448369	2·230304	·9124775	51
10	·4093923	·448718	2·228567	·9123584	50
11	·4096577	·449068	2·226833	·9122393	49
12	·4099230	·449417	2·225100	·9121201	48
13	·4101883	·449767	2·223370	·9120008	47
14	·4104536	·450117	2·221643	·9118815	46
15	·4107189	·450467	2·219917	·9117620	45
16	·4109841	·450817	2·218194	·9116425	44
17	·4112492	·451167	2·216473	·9115229	43
18	·4115144	·451517	2·214754	·9114033	42
19	·4117795	·451867	2·213037	·9112835	41
20	·4120445	·452217	2·211323	·9111637	40
21	·4123096	·452568	2·209611	·9110438	39
22	·4125745	·452918	2·207901	·9109238	38
23	·4128395	·453269	2·206193	·9108038	37
24	·4131044	·453620	2·204487	·9106837	36
25	·4133693	·453970	2·202784	·9105635	35
26	·4136342	·454321	2·201083	·9104432	34
27	·4138990	·454672	2·199384	·9103228	33
28	·4141638	·455023	2·197687	·9102024	32
29	·4144285	·455375	2·195992	·9100819	31
30	·4146932	·455726	2·194299	·9099613	30
'	COSINE.	COTANG.	TANG.	SINE.	'

24 Deg.   **Deg. 65.**

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·4149579	·456077	2·192609	·9098406	29
32	·4152226	·456429	2·190921	·9097199	28
33	·4154872	·456780	2·189234	·9095990	27
34	·4157517	·457132	2·187551	·9094781	26
35	·4160163	·457483	2·185869	·9093572	25
36	·4162808	·457835	2·184189	·9092361	24
37	·4165453	·458187	2·182511	·9091150	23
38	·4168097	·458539	2·180836	·9089938	22
39	·4170741	·458891	2·179163	·9088725	21
40	·4173385	·459243	2·177492	·9087511	20
41	·4176028	·459596	2·175822	·9086297	19
42	·4178671	·459948	2·174155	·9085082	18
43	·4181313	·460301	2·172491	·9083866	17
44	·4183956	·460653	2·170828	·9082649	16
45	·4186597	·461006	2·169167	·9081432	15
46	·4189239	·461359	2·167509	·9080214	14
47	·4191880	·461711	2·165852	·9078995	13
48	·4194521	·462064	2·164198	·9077775	12
49	·4197161	·462417	2·162546	·9076554	11
50	·4199801	·462771	2·160895	·9075333	10
51	·4202441	·463124	2·159247	·9074111	9
52	·4205080	·463477	2·157601	·9072888	8
53	·4207719	·463831	2·155957	·9071665	7
54	·4210358	·464184	2·154315	·9070440	6
55	·4212966	·464538	2·152675	·9069215	5
56	·4215634	·464892	2·151037	·9067989	4
57	·4218272	·465245	2·149402	·9066762	3
58	·4220909	·465599	2·147768	·9065535	2
59	·4223546	·465953	2·146136	·9064307	1
60	·4226183	·466307	2·144506	·9063078	0
'	COSINE.	COTANG.	TANG.	SINE.	'

NATURAL SINES AND TANGENTS TO A RADIUS 1.

25 Deg.

/	SINE.	TANG.	COTANG.	COSINE.	/
0	.4226183	.466307	2.144506	.9063078	60
1	.4228819	.466661	2.142879	.9061848	59
2	.4231455	.467016	2.141253	.9060618	58
3	.4234090	.467370	2.139630	.9059386	57
4	.4236725	.467725	2.138008	.9058154	56
5	.4239360	.468079	2.136389	.9056922	55
6	.4241994	.468434	2.134771	.9055688	54
7	.4244628	.468789	2.133155	.9054454	53
8	.4247262	.469143	2.131542	.9053219	52
9	.4249895	.469498	2.129930	.9051983	51
10	.4252528	.469853	2.128321	.9050746	50
11	.4255161	.470209	2.126713	.9049509	49
12	.4257793	.470564	2.125108	.9048271	48
13	.4260425	.470919	2.123504	.9047032	47
14	.4263056	.471275	2.121903	.9045792	46
15	.4265687	.471630	2.120303	.9044551	45
16	.4268318	.471986	2.118705	.9043310	44
17	.4270949	.472342	2.117110	.9042068	43
18	.4273579	.472697	2.115516	.9040825	42
19	.4276208	.473053	2.113924	.9039582	41
20	.4278838	.473409	2.112334	.9038338	40
21	.4281467	.473765	2.110747	.9037093	39
22	.4284095	.474122	2.109161	.9035847	38
23	.4286723	.474478	2.107577	.9034600	37
24	.4289351	.474834	2.105995	.9033353	36
25	.4291979	.475191	2.104415	.9032105	35
26	.4294606	.475548	2.102836	.9030856	34
27	.4297233	.475904	2.101260	.9029606	33
28	.4299859	.476261	2.099686	.9028356	32
29	.4302485	.476618	2.098114	.9027105	31
30	.4305111	.476975	2.096543	.9025853	30
/	COSINE.	TANG.	COTANG.	SINE.	/

Deg. 64.

25 Deg.

/	SINE.	TANG.	COTANG.	COSINE.	/
31	.4307736	.477332	2.094975	.9024600	29
32	.4310361	.477689	2.093408	.9023347	28
33	.4312986	.478047	2.091843	.9022092	27
34	.4315610	.478404	2.090280	.9020838	26
35	.4318234	.478762	2.088720	.9019582	25
36	.4320857	.479119	2.087161	.9018325	24
37	.4323481	.479477	2.085603	.9017068	23
38	.4326103	.479835	2.084048	.9015810	22
39	.4328726	.480193	2.082495	.9014551	21
40	.4331348	.480551	2.080943	.9013292	20
41	.4333970	.480909	2.079394	.9012031	19
42	.4336591	.481267	2.077846	.9010770	18
43	.4339212	.481625	2.076300	.9009508	17
44	.4341832	.481984	2.074756	.9008246	16
45	.4344453	.482342	2.073214	.9006982	15
46	.4347072	.482701	2.071674	.9005718	14
47	.4349692	.483060	2.070135	.9004453	13
48	.4352311	.483418	2.068599	.9003188	12
49	.4354930	.483777	2.067064	.9001921	11
50	.4357548	.484136	2.065531	.9000654	10
51	.4360166	.484495	2.064000	.8999386	9
52	.4362784	.484855	2.062471	.8998117	8
53	.4365401	.485214	2.060944	.8996848	7
54	.4368018	.485573	2.059418	.8995578	6
55	.4370634	.485933	2.057895	.8994307	5
56	.4373251	.486293	2.056373	.8993035	4
57	.4375866	.486652	2.054853	.8991763	3
58	.4378482	.487012	2.053334	.8990489	2
59	.4381097	.487372	2.051818	.8989215	1
60	.4383711	.487732	2.050303	.8987940	0
/	COSINE.	TANG.	COTANG.	SINE.	/

Deg. 64.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

26 Deg. | | | | **25 Deg.**

′	SINE	TANG.	COTANG.		′	′	SINE	TANG.	COTANG.	COSINE	′
0	·4383711	·487732	2·050303		60	31	·4464581	·498944	2·004229	·8948045	29
1	·4386326	·488092	2·048791		59	32	·4467184	·499308	2·002771	·8946746	28
2	·4388940	·488453	2·047280		58	33	·4469786	·499671	2·001314	·8945446	27
3	·4391553	·488813	2·045770		57	34	·4472388	·500035	1·999859	·8944146	26
4	·4394166	·489173	2·044263		56	35	·4474990	·500398	1·998405	·8942844	25
5	·4396779	·489534	2·042757		55	36	·4477591	·500762	1·996953	·8941542	24
6	·4399392	·489894	2·041254		54	37	·4480192	·501126	1·995503	·8940240	23
7	·4402004	·490255	2·039751		53	38	·4482792	·501490	1·994055	·8938936	22
8	·4404615	·490616	2·038251		52	39	·4485392	·501854	1·992608	·8937632	21
9	·4407227	·490977	2·036753		51	40	·4487992	·502218	1·991163	·8936326	20
10	·4409838	·491338	2·035256		50	41	·4490591	·502583	1·989720	·8935021	19
11	·4412448	·491699	2·033761		49	42	·4493190	·502947	1·988278	·8933714	18
12	·4415059	·492061	2·032268		48	43	·4495789	·503312	1·986838	·8932406	17
13	·4417668	·492422	2·030776		47	44	·4498387	·503676	1·985400	·8931098	16
14	·4420278	·492783	2·029287		46	45	·4500984	·504041	1·983963	·8929789	15
15	·4422887	·493145	2·027799		45	46	·4503582	·504406	1·982528	·8928479	14
16	·4425496	·493507	2·026313		44	47	·4506179	·504771	1·981095	·8927169	13
17	·4428104	·493868	2·024828		43	48	·4508775	·505136	1·979663	·8925858	12
18	·4430712	·494230	2·023346		42	49	·4511372	·505501	1·978233	·8924546	11
19	·4433319	·494592	2·021865		41	50	·4513967	·505866	1·976805	·8923234	10
20	·4435927	·494954	2·020386		40	51	·4516563	·506232	1·975378	·8921920	9
21	·4438534	·495317	2·018908		39	52	·4519158	·506597	1·973953	·8920606	8
22	·4441140	·495679	2·017433		38	53	·4521753	·506963	1·972529	·8919291	7
23	·4443746	·496041	2·015959		37	54	·4524347	·507329	1·971107	·8917975	6
24	·4446352	·496404	2·014486		36	55	·4526941	·507694	1·969687	·8916659	5
25	·4448957	·496766	2·013016		35	56	·4529535	·508060	1·968268	·8915342	4
26	·4451562	·497129	2·011547		34	57	·4532128	·508426	1·966851	·8914024	3
27	·4454167	·497492	2·010080		33	58	·4534721	·508792	1·965436	·8912705	2
28	·4456771	·497855	2·008615		32	59	·4537313	·509159	1·964022	·8911385	1
29	·4459375	·498218	2·007151		31	60	·4539905	·509525	1·962610	·8910065	0
30	·4461978	·498581	2·005689		30						′
′	COSINE.	COTANG.	TANG.		SINE.		COSINE.	COTANG.	TANG.	SINE.	

Deg. 63. | | | | | | | | | | **Deg. 63.**

NATURAL SINES AND TANGENTS TO A RADIUS 1.

27 Deg.

′	SINE.	TANG.	COTANG.	COSINE.
0	.4539905	.509325	1.962610	.8910065
1	.4542497	.509891	1.961200	.8908744
2	.4545088	.510258	1.959791	.8907423
3	.4547679	.510625	1.958383	.8906100
4	.4550269	.510991	1.956978	.8904777
5	.4552859	.511358	1.955573	.8903453
6	.4555449	.511725	1.954171	.8902128
7	.4558038	.512093	1.952770	.8900803
8	.4560627	.512460	1.951371	.8899476
9	.4563216	.512827	1.949973	.8898149
10	.4565804	.513195	1.948577	.8896822
11	.4568392	.513562	1.947182	.8895493
12	.4570979	.513930	1.945789	.8894164
13	.4573566	.514298	1.944398	.8892834
14	.4576153	.514665	1.943008	.8891503
15	.4578739	.515033	1.941620	.8890171
16	.4581325	.515401	1.940233	.8888839
17	.4583910	.515770	1.938848	.8887506
18	.4586496	.516138	1.937464	.8886172
19	.4589080	.516506	1.936082	.8884838
20	.4591665	.516875	1.934702	.8883503
21	.4594248	.517244	1.933323	.8882166
22	.4596832	.517612	1.931945	.8880830
23	.4599415	.517981	1.930569	.8879492
24	.4601998	.518350	1.929195	.8878154
25	.4604580	.518719	1.927822	.8876815
26	.4607162	.519089	1.926451	.8875475
27	.4609744	.519458	1.925081	.8874134
28	.4612325	.519827	1.923713	.8872793
29	.4614906	.520197	1.922347	.8871451
30	.4617486	.520567	1.920982	.8870108
′	COSINE.	COTANG.	TANG.	SINE.

Deg. 62.

27 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.4620066	.520935	1.919018	.8908765	29
32	.4622646	.521306	1.917656	.8907420	28
33	.4625225	.521676	1.916896	.8906075	27
34	.4627804	.522046	1.915537	.8904730	26
35	.4630382	.522417	1.914179	.8903383	25
36	.4632960	.522787	1.912823	.8902036	24
37	.4635538	.523157	1.911469	.8900688	23
38	.4638115	.523528	1.910116	.8899339	22
39	.4640692	.523899	1.908764	.8897989	21
40	.4643269	.524269	1.907414	.8896639	20
41	.4645845	.524640	1.906066	.8895288	19
42	.4648420	.525011	1.904719	.8893936	18
43	.4650996	.525382	1.903373	.8892584	17
44	.4653571	.525754	1.902029	.8891230	16
45	.4656145	.526125	1.900687	.8889876	15
46	.4658719	.526496	1.899346	.8888521	14
47	.4661293	.526868	1.898006	.8887166	13
48	.4663866	.527240	1.896668	.8885810	12
49	.4666439	.527612	1.895332	.8884453	11
50	.4669012	.527983	1.893997	.8843095	10
51	.4671584	.528356	1.892663	.8841736	9
52	.4674156	.528728	1.891331	.8840377	8
53	.4676727	.529100	1.890000	.8839017	7
54	.4679298	.529472	1.888671	.8837656	6
55	.4681869	.529845	1.887343	.8836295	5
56	.4684439	.530217	1.886017	.8834933	4
57	.4687009	.530590	1.884692	.8833571	3
58	.4689578	.530963	1.883369	.8832206	2
59	.4692147	.531336	1.882047	.8830841	1
60	.4694716	.531709	1.880726	.8829476	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 62.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

28 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.4694716	.531709	1.880726	.8829476	60
1	.4697284	.532082	1.879407	.8828110	59
2	.4699852	.532455	1.878089	.8826743	58
3	.4702419	.532829	1.876773	.8825376	57
4	.4704986	.533202	1.875458	.8824007	56
5	.4707553	.533576	1.874145	.8822638	55
6	.4710119	.533950	1.872833	.8821269	54
7	.4712685	.534324	1.871523	.8819898	53
8	.4715250	.534698	1.870214	.8818527	52
9	.4717815	.535072	1.868906	.8817155	51
10	.4720380	.535446	1.867600	.8815782	50
11	.4722944	.535820	1.866295	.8814409	49
12	.4725508	.536195	1.864992	.8813035	48
13	.4728071	.536569	1.863690	.8811660	47
14	.4730634	.536944	1.862389	.8810284	46
15	.4733197	.537319	1.861090	.8808907	45
16	.4735759	.537694	1.859792	.8807530	44
17	.4738321	.538069	1.858495	.8806152	43
18	.4740882	.538444	1.857201	.8804774	42
19	.4743443	.538819	1.855908	.8803394	41
20	.4746004	.539195	1.854615	.8802014	40
21	.4748564	.539570	1.853325	.8800633	39
22	.4751124	.539946	1.852035	.8799252	38
23	.4753683	.540322	1.850747	.8797869	37
24	.4756242	.540698	1.849461	.8796486	36
25	.4758801	.541074	1.848176	.8795102	35
26	.4761359	.541450	1.846892	.8793717	34
27	.4763917	.541826	1.845609	.8792332	33
28	.4766474	.542202	1.844328	.8790946	32
29	.4769031	.542579	1.843049	.8789559	31
30	.4771588	.542955	1.841770	.8788171	30
COSINE.	COTANG.	TANG.	SINE.		Deg. 61.

28 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.4774144	.543332	1.840494	.8786783	29
32	.4776700	.543709	1.839218	.8785394	28
33	.4779255	.544086	1.837944	.8784004	27
34	.4781810	.544463	1.836671	.8782613	26
35	.4784364	.544840	1.835399	.8781222	25
36	.4786919	.545217	1.834129	.8779830	24
37	.4789472	.545595	1.832861	.8778437	23
38	.4792026	.545972	1.831593	.8777043	22
39	.4794579	.546350	1.830327	.8775649	21
40	.4797131	.546728	1.829062	.8774254	20
41	.4799683	.547106	1.827799	.8772858	19
42	.4802235	.547484	1.826537	.8771462	18
43	.4804786	.547862	1.825276	.8770064	17
44	.4807337	.548240	1.824017	.8768666	16
45	.4809888	.548618	1.822759	.8767268	15
46	.4812438	.548997	1.821502	.8765868	14
47	.4814987	.549375	1.820247	.8764468	13
48	.4817537	.549754	1.818993	.8763067	12
49	.4820086	.550133	1.817740	.8761665	11
50	.4822634	.550512	1.816489	.8760263	10
51	.4825182	.550891	1.815239	.8758859	9
52	.4827730	.551270	1.813990	.8757455	8
53	.4830277	.551650	1.812743	.8756051	7
54	.4832824	.552029	1.811496	.8754645	6
55	.4835370	.552409	1.810252	.8753239	5
56	.4837916	.552789	1.809008	.8751832	4
57	.4840462	.553168	1.807766	.8750425	3
58	.4843007	.553548	1.806525	.8749016	2
59	.4845552	.553928	1.805286	.8747607	1
60	.4848096	.554309	1.804047	.8746197	0
COSINE.	COTANG.	TANG.	SINE.		Deg. 61.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

29 Deg.

Minutes 0–30

'	SINE.	TANG.	COTANG.	COSINE.	'
0	4848096	554309	1804047	8746197	60
1	4850640	554689	1802810	8744786	59
2	4853184	555069	1801575	8743375	58
3	4855727	555450	1800340	8741963	57
4	4858270	555831	1799107	8740550	56
5	4860812	556211	1797875	8739137	55
6	4863354	556592	1796645	8737722	54
7	4865895	556973	1795416	8736307	53
8	4868436	557355	1794188	8734891	52
9	4870977	557736	1792961	8733475	51
10	4873517	558117	1791736	8732058	50
11	4876057	558499	1790512	8730640	49
12	4878597	558881	1789289	8729221	48
13	4881136	559262	1788067	8727801	47
14	4883674	559644	1786847	8726381	46
15	4886212	560026	1785628	8724960	45
16	4888750	560408	1784410	8723538	44
17	4891288	560791	1783194	8722116	43
18	4893825	561173	1781979	8720693	42
19	4896361	561556	1780765	8719269	41
20	4898897	561939	1779552	8717844	40
21	4901433	562321	1778341	8716419	39
22	4903968	562704	1777130	8714993	38
23	4906503	563087	1775921	8713566	37
24	4909038	563471	1774714	8712138	36
25	4911572	563854	1773507	8710710	35
26	4914105	564237	1772302	8709281	34
27	4916639	564621	1771098	8707851	33
28	4919171	565005	1769895	8706420	32
29	4921704	565388	1768694	8704989	31
30	4924236	565772	1767494	8703557	30

(bottom labels: COSINE. — COTANG. — TANG. — SINE. Deg. 60.)

Minutes 31–60

'	SINE.	TANG.	COTANG.	COSINE.	'
31	4926767	566156	1766295	8702124	29
32	4929293	566541	1765097	8700691	28
33	4931829	566925	1763900	8699256	27
34	4934359	567309	1762705	8697821	26
35	4936889	567694	1761511	8696386	25
36	4939419	568079	1760318	8694949	24
37	4941948	568463	1759126	8693512	23
38	4944476	568848	1757936	8692074	22
39	4947005	569233	1756747	8690636	21
40	4949532	569619	1755559	8689196	20
41	4952060	570004	1754372	8687756	19
42	4954587	570389	1753186	8686315	18
43	4957113	570775	1752002	8684874	17
44	4959639	571161	1750819	8683431	16
45	4962165	571547	1749637	8681988	15
46	4964690	571933	1748456	8680544	14
47	4967215	572319	1747276	8679100	13
48	4969740	572705	1746098	8677655	12
49	4972264	573091	1744921	8676209	11
50	4974787	573478	1743745	8674762	10
51	4977310	573864	1742570	8673314	9
52	4979833	574251	1741396	8671866	8
53	4982355	574638	1740224	8670417	7
54	4984877	575025	1739053	8668967	6
55	4987399	575412	1737883	8667517	5
56	4989920	575799	1736714	8666066	4
57	4992441	576187	1735546	8664614	3
58	4994961	576574	1734380	8663161	2
59	4997481	576962	1733214	8661708	1
60	5000000	577350	1732050	8660254	0

(bottom labels: COSINE. — COTANG. — TANG. — SINE. Deg. 60.)

NATURAL SINES AND TANGENTS TO A RADIUS 1.

30 DEG.

′	COSINE.	COTANG.	TANG.	SINE.	′
29	·8614815	1·696634	·589436	·5077930	31
28	·8613337	1·694406	·588828	·5080386	32
27	·8611859	1·694280	·590221	·5082901	33
26	·8610380	1·693155	·590013	·5085406	34
25	·8608901	1·692030	·591005	·5087910	35
24	·8607420	1·690907	·591398	·5090414	36
23	·8605939	1·689785	·591791	·5092918	37
22	·8604457	1·688664	·592183	·5095421	38
21	·8602975	1·687544	·592576	·5097924	39
20	·8601491	1·686426	·592969	·5100426	40
19	·8600007	1·685308	·593363	·5102928	41
18	·8598523	1·684191	·593756	·5105429	42
17	·8597037	1·683076	·594150	·5107930	43
16	·8595551	1·681962	·594543	·5110431	44
15	·8594064	1·680848	·594937	·5112931	45
14	·8592576	1·679736	·595331	·5115431	46
13	·8591088	1·678625	·595725	·5117930	47
12	·8589599	1·677515	·596119	·5120429	48
11	·8588109	1·676406	·596514	·5122927	49
10	·8586619	1·675298	·596908	·5125425	50
9	·8585127	1·674192	·597303	·5127923	51
8	·8583635	1·673086	·597697	·5130420	52
7	·8582143	1·673085	·598092	·5132916	53
6	·8580649	1·671901	·598487	·5135413	54
5	·8579155	1·670785	·598882	·5137908	55
4	·8577660	1·669675	·599278	·5140404	56
3	·8576164	1·668754	·599673	·5142899	57
2	·8574668	1·666644	·600069	·5145393	58
1	·8573171	1·665576	·600464	·5147887	59
0	·8571673	1·664279	·600860	·5150381	60
′	SINE.	TANG.	COTANG.	COSINE.	′

DEG. 59.

30 DEG.

′	SINE.	TANG.	COTANG.	COSINE.	′
0	·5000000	·577350	1·732050	·8660254	60
1	·5002519	·577738	1·730857	·8658799	59
2	·5005037	·578126	1·729726	·8657344	58
3	·5007556	·578514	1·728565	·8655887	57
4	·5010073	·578902	1·727406	·8654430	56
5	·5012591	·579291	1·726247	·8652973	55
6	·5015107	·579679	1·725090	·8651514	54
7	·5017624	·580068	1·723934	·8650055	53
8	·5020140	·580457	1·722779	·8648595	52
9	·5022655	·580846	1·721626	·8647134	51
10	·5025170	·581235	1·720473	·8645673	50
11	·5027685	·581624	1·719322	·8644211	49
12	·5030199	·582013	1·718172	·8642748	48
13	·5032713	·582403	1·717023	·8641284	47
14	·5035227	·582792	1·715875	·8639820	46
15	·5037740	·583182	1·714728	·8638355	45
16	·5040252	·583572	1·713582	·8636889	44
17	·5042765	·583962	1·712438	·8635423	43
18	·5045276	·584352	1·711294	·8633956	42
19	·5047743	·584743	1·710152	·8632488	41
20	·5050298	·585133	1·709011	·8631019	40
21	·5052809	·585524	1·707871	·8629549	39
22	·5055319	·585914	1·706732	·8628079	38
23	·5057828	·586305	1·705595	·8626608	37
24	·5060338	·586696	1·704458	·8625137	36
25	·5062846	·587087	1·703323	·8623664	35
26	·5065355	·587478	1·702189	·8622191	34
27	·5067863	·587869	1·701055	·8620717	33
28	·5070370	·588261	1·699923	·8619243	32
29	·5072877	·588653	1·698792	·8617768	31
30	·5075384	·589045	1·697663	·8616292	30
′	COSINE.	COTANG.	TANG.	SINE.	′

DEG. 59.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

31 DEG.

'	SINE.	TANG.	COTANG.	COSINE.
0	·5150381	·600830	1·664279	·8571673
1	·5152874	·601256	1·663183	·8570174
2	·5155367	·601652	1·662088	·8568675
3	·5157859	·602049	1·660994	·8567175
4	·5160351	·602445	1·659901	·8565674
5	·5162842	·602841	1·658809	·8564173
6	·5165333	·603238	1·657718	·8562671
7	·5167824	·603635	1·656629	·8561168
8	·5170314	·604032	1·655540	·8559664
9	·5172804	·604429	1·654452	·8558160
10	·5175293	·604826	1·653366	·8556655
11	·5177782	·605224	1·652280	·8555149
12	·5180270	·605621	1·651196	·8553643
13	·5182758	·606019	1·650112	·8552135
14	·5185246	·606417	1·649030	·8550627
15	·5187733	·606814	1·647949	·8549119
16	·5190219	·607213	1·646868	·8547609
17	·5192705	·607611	1·645789	·8546099
18	·5195191	·608009	1·644711	·8544588
19	·5197676	·608408	1·643633	·8543077
20	·5200161	·608806	1·642557	·8541564
21	·5202646	·609205	1·641482	·8540051
22	·5205130	·609604	1·640408	·8538538
23	·5207613	·610003	1·639335	·8537023
24	·5210096	·610402	1·638263	·8535508
25	·5212579	·610801	1·637191	·8533992
26	·5215061	·611201	1·636121	·8532475
27	·5217543	·611601	1·635052	·8530958
28	·5220024	·612000	1·633984	·8529440
29	·5222505	·612400	1·632917	·8527921
30	·5224986	·612800	1·631851	·8526402
'	COSINE.	COTANG.	TANG.	SINE.

31 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·5227466	·613201	1·630786	·8524881	29
32	·5229945	·613601	1·629722	·8523380	28
33	·5232424	·614001	1·628659	·8521880	27
34	·5234903	·614402	1·627597	·8520316	26
35	·5237381	·614803	1·626536	·8518743	25
36	·5239859	·615204	1·625476	·8517269	24
37	·5242336	·615605	1·624417	·8515745	23
38	·5244813	·616006	1·623359	·8514219	22
39	·5247290	·616407	1·622302	·8512693	21
40	·5249766	·616809	1·621246	·8511167	20
41	·5252241	·617210	1·620192	·8509639	19
42	·5254717	·617612	1·619138	·8508111	18
43	·5257191	·618014	1·618085	·8506582	17
44	·5259665	·618416	1·617033	·8505053	16
45	·5262139	·618818	1·615982	·8503522	15
46	·5264613	·619221	1·614932	·8501991	14
47	·5267085	·619623	1·613882	·8500459	13
48	·5269558	·620026	1·612834	·8498927	12
49	·5272030	·620429	1·611787	·8497394	11
50	·5274502	·620832	1·610741	·8495860	10
51	·5276973	·621235	1·609696	·8494325	9
52	·5279443	·621638	1·608652	·8492790	8
53	·5281914	·622041	1·607609	·8491254	7
54	·5284383	·622445	1·606567	·8489717	6
55	·5286853	·622848	1·605526	·8488179	5
56	·5289322	·623252	1·604485	·8486641	4
57	·5291790	·623656	1·603446	·8485102	3
58	·5294258	·624060	1·602408	·8483562	2
59	·5296726	·624465	1·601370	·8482022	1
60	·5299193	·624869	1·600334	·8480481	0
'	COSINE.	COTANG.	TANG.	SINE.	'

NATURAL SINES AND TANGENTS TO A RADIUS 1.

32 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·5299193	·624869	1·600334	·8480481	60
1	·5301659	·625273	1·599299	·8478839	59
2	·5304125	·625678	1·598264	·8477397	58
3	·5306591	·626083	1·597231	·8475853	57
4	·5309057	·626488	1·596198	·8474309	56
5	·5311521	·626893	1·595167	·8472765	55
6	·5313986	·627298	1·594136	·8471219	54
7	·5316450	·627704	1·593107	·8469673	53
8	·5318913	·628109	1·592078	·8468126	52
9	·5321376	·628515	1·591050	·8466579	51
10	·5323839	·628921	1·590023	·8465030	50
11	·5326301	·629327	1·588997	·8463481	49
12	·5328763	·629733	1·587973	·8461932	48
13	·5331224	·630139	1·586949	·8460381	47
14	·5333685	·630546	1·585926	·8458830	46
15	·5336145	·630953	1·584904	·8457278	45
16	·5338605	·631359	1·583883	·8455726	44
17	·5341065	·631766	1·582862	·8454172	43
18	·5343523	·632173	1·581843	·8452618	42
19	·5345982	·632581	1·580825	·8451064	41
20	·5348440	·632988	1·579807	·8449508	40
21	·5350898	·633395	1·578791	·8447952	39
22	·5353355	·633803	1·577776	·8446395	38
23	·5355812	·634211	1·576761	·8444838	37
24	·5358268	·634619	1·575747	·8443279	36
25	·5360724	·635027	1·574735	·8441720	35
26	·5363179	·635435	1·573723	·8440161	34
27	·5365634	·635844	1·572712	·8438600	33
28	·5368089	·636252	1·571702	·8437039	32
29	·5370543	·636661	1·570693	·8435477	31
30	·5372996	·637070	1·569685	·8433914	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 57.

32 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·5375449	·637479	1·568678	·8432351	29
32	·5377902	·637888	1·567672	·8430787	28
33	·5380354	·638297	1·566666	·8429222	27
34	·5382806	·638707	1·565662	·8427657	26
35	·5385257	·639116	1·564659	·8426091	25
36	·5387708	·639526	1·563656	·8424524	24
37	·5390158	·639936	1·562654	·8422956	23
38	·5392608	·640346	1·561654	·8421388	22
39	·5395058	·640756	1·560654	·8419819	21
40	·5397507	·641167	1·559655	·8418249	20
41	·5399955	·641577	1·558657	·8416679	19
42	·5402403	·641988	1·557660	·8415108	18
43	·5404851	·642399	1·556663	·8413536	17
44	·5407298	·642810	1·555668	·8411963	16
45	·5409745	·643221	1·554674	·8410390	15
46	·5412191	·643632	1·553680	·8408816	14
47	·5414637	·644044	1·552688	·8407241	13
48	·5417082	·644456	1·551696	·8405666	12
49	·5419527	·644867	1·550705	·8404090	11
50	·5421971	·645279	1·549715	·8402513	10
51	·5424415	·645691	1·548726	·8400936	9
52	·5426859	·646104	1·547738	·8399357	8
53	·5429302	·646516	1·546751	·8397778	7
54	·5431744	·646929	1·545764	·8396199	6
55	·5434187	·647341	1·544779	·8394618	5
56	·5436628	·647754	1·543794	·8393037	4
57	·5439069	·648167	1·542810	·8391455	3
58	·5441510	·648580	1·541828	·8389873	2
59	·5443951	·648994	1·540846	·8388290	1
60	·5446390	·649407	1·539865	·8386706	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 57.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

33 Deg. / Deg. 56.

′	SINE	TANG	COTANG	COSINE
0	.5446390	.649407	1.538965	.8386706
1	.5448830	.649821	1.538584	.8385121
2	.5451269	.650235	1.537905	.8383536
3	.5453707	.650649	1.536927	.8381950
4	.5456145	.651063	1.535949	.8380363
5	.5458583	.651477	1.534972	.8378775
6	.5461020	.651891	1.533996	.8377187
7	.5463456	.652306	1.533021	.8375598
8	.5465892	.652721	1.532047	.8374009
9	.5468328	.653136	1.531074	.8372418
10	.5470763	.653551	1.530102	.8370827
11	.5473198	.653966	1.529130	.8369236
12	.5475632	.654381	1.528160	.8367643
13	.5478066	.654797	1.527190	.8366050
14	.5480499	.655212	1.526221	.8364456
15	.5482932	.655628	1.525253	.8362862
16	.5485365	.656044	1.524286	.8361266
17	.5487797	.656460	1.523320	.8359670
18	.5490228	.656877	1.522354	.8358074
19	.5492659	.657293	1.521389	.8356476
20	.5495090	.657710	1.520426	.8354878
21	.5497520	.658127	1.519463	.8353279
22	.5499950	.658544	1.518501	.8351680
23	.5502379	.658961	1.517540	.8350080
24	.5504807	.659378	1.516579	.8348479
25	.5507236	.659796	1.515620	.8346877
26	.5509663	.660213	1.514661	.8345275
27	.5512091	.660631	1.513703	.8343672
28	.5514518	.661049	1.512746	.8342068
29	.5516944	.661467	1.511790	.8340463
30	.5519370	.661885	1.510835	.8338858

(Bottom labels for Deg. 56: COSINE | COTANG | TANG | SINE)

33 Deg. / Deg. 56.

′	SINE	TANG	COTANG	COSINE	′
31	.5621795	.662304	1.509880	.8337252	29
32	.5624220	.662722	1.508927	.8335646	28
33	.5626645	.663141	1.507974	.8334038	27
34	.5629069	.663560	1.507022	.8332430	26
35	.5631492	.663979	1.506071	.8330822	25
36	.5633915	.664398	1.505121	.8329212	24
37	.5636338	.664817	1.504171	.8327602	23
38	.5638760	.665237	1.503222	.8325991	22
39	.5641182	.665657	1.502275	.8324380	21
40	.5643603	.666076	1.501328	.8322768	20
41	.5646024	.666496	1.500382	.8321155	19
42	.5648444	.666917	1.499436	.8319541	18
43	.5650864	.667337	1.498492	.8317927	17
44	.5653283	.667758	1.497548	.8316312	16
45	.5655701	.668178	1.496605	.8314696	15
46	.5658121	.668599	1.495663	.8313080	14
47	.5660539	.669020	1.494722	.8311463	13
48	.5662956	.669441	1.493782	.8309845	12
49	.5665373	.669863	1.492842	.8308226	11
50	.5667790	.670284	1.491903	.8306607	10
51	.5670206	.670706	1.490965	.8304987	9
52	.5672621	.671128	1.490028	.8303366	8
53	.5675036	.671550	1.489092	.8301745	7
54	.5677451	.671972	1.488157	.8300123	6
55	.5679865	.672394	1.487222	.8298500	5
56	.5682279	.672816	1.486288	.8296877	4
57	.5684692	.673239	1.485355	.8295252	3
58	.5687105	.673662	1.484423	.8293628	2
59	.5689517	.674085	1.483491	.8292002	1
60	.5691929	.674508	1.482561	.8290376	0

(Bottom labels for Deg. 56: SINE | COSINE | COTANG | TANG | COSINE | SINE)

9

NATURAL SINES AND TANGENTS TO A RADIUS 1.

34 Deg.

′	SINE.	TANG.	COTANG.	COSINE.
0	.5591929	.674508	1.482561	.8290876
1	.5594340	.674931	1.481631	.8288749
2	.5596751	.675355	1.480702	.8287121
3	.5599162	.675779	1.479773	.8285493
4	.5601572	.676202	1.478846	.8283864
5	.5603981	.676626	1.477919	.8282234
6	.5606390	.677050	1.476993	.8280603
7	.5608798	.677475	1.476068	.8278972
8	.5611206	.677899	1.475144	.8277340
9	.5613614	.678324	1.474221	.8275708
10	.5616021	.678749	1.473298	.8274074
11	.5618428	.679174	1.472376	.8272440
12	.5620834	.679599	1.471455	.8270806
13	.5623239	.680024	1.470535	.8269170
14	.5625645	.680450	1.469615	.8267534
15	.5628049	.680875	1.468696	.8265897
16	.5630453	.681301	1.467778	.8264260
17	.5632857	.681727	1.466861	.8262622
18	.5635260	.682153	1.465945	.8260983
19	.5637663	.682580	1.465029	.8259343
20	.5640066	.683006	1.464114	.8257703
21	.5642467	.683433	1.463200	.8256062
22	.5644869	.683860	1.462287	.8254420
23	.5647270	.684287	1.461374	.8252778
24	.5649670	.684714	1.460463	.8251135
25	.5652070	.685141	1.459552	.8249491
26	.5654469	.685569	1.458642	.8247847
27	.5656868	.685996	1.457732	.8246202
28	.5659267	.686424	1.456824	.8244556
29	.5661665	.686852	1.455916	.8242909
30	.5664062	.687281	1.455009	.8241262
′	COSINE.	COTANG.	TANG.	SINE.

Deg. 55

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.5666469	.687709	1.454102	.8239614	29
32	.5668856	.688137	1.453197	.8237995	28
33	.5671252	.688566	1.452292	.8236316	27
34	.5673648	.688995	1.451388	.8234666	26
35	.5676043	.689424	1.450485	.8233015	25
36	.5678437	.689853	1.449582	.8231364	24
37	.5680832	.690283	1.448680	.8229712	23
38	.5683225	.690712	1.447779	.8228059	22
39	.5685619	.691142	1.446879	.8226405	21
40	.5688011	.691572	1.445980	.8224751	20
41	.5690403	.692002	1.445081	.8223096	19
42	.5692795	.692432	1.444183	.8221440	18
43	.5695187	.692863	1.443286	.8219784	17
44	.5697577	.693293	1.442389	.8218127	16
45	.5699968	.693724	1.441494	.8216469	15
46	.5702357	.694155	1.440599	.8214811	14
47	.5704747	.694586	1.439704	.8213152	13
48	.5707136	.695018	1.438811	.8211492	12
49	.5709524	.695449	1.437918	.8209832	11
50	.5711912	.695881	1.437026	.8208170	10
51	.5714299	.696313	1.436135	.8206509	9
52	.5716686	.696745	1.435245	.8204846	8
53	.5719073	.697177	1.434355	.8203183	7
54	.5721459	.697609	1.433466	.8201519	6
55	.5723844	.698042	1.432578	.8199854	5
56	.5726229	.698474	1.431690	.8198189	4
57	.5728614	.698907	1.430803	.8196523	3
58	.5730998	.699340	1.429917	.8194856	2
59	.5733381	.699774	1.429032	.8193189	1
60	.5735764	.700207	1.428148	.8191520	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 55

NATURAL SINES AND TANGENTS TO A RADIUS 1.

35 DEG.

'	SINE.	TANG.	COTANG.	COSINE.
0	5735764	700207	1·428148	8191520
1	5738147	700641	1·427264	8189852
2	5740529	701074	1·426381	8188182
3	5742911	701508	1·425498	8186512
4	5745292	701943	1·424617	8184841
5	5747672	702377	1·423736	8183169
6	5750053	702811	1·422856	8181497
7	5752432	703246	1·421976	8179824
8	5754811	703681	1·421097	8178151
9	5757190	704116	1·420220	8176476
10	5759568	704551	1·419342	8174801
11	5761946	704986	1·418466	8173125
12	5764323	705422	1·417590	8171449
13	5766700	705858	1·416715	8169772
14	5769076	706294	1·415840	8168094
15	5771452	706730	1·414967	8166416
16	5773827	707166	1·414094	8164736
17	5776202	707602	1·413222	8163056
18	5778576	708039	1·412350	8161376
19	5780950	708476	1·411479	8159695
20	5783323	708913	1·410609	8158013
21	5785696	709350	1·409740	8156330
22	5788069	709787	1·408871	8154647
23	5790440	710225	1·408003	8152963
24	5792812	710663	1·407136	8151278
25	5795183	711100	1·406270	8149593
26	5797553	711539	1·405404	8147906
27	5799923	711977	1·404539	8146220
28	5802292	712415	1·403674	8144532
29	5804661	712854	1·402811	8142844
30	5807030	713293	1·401948	8141155
	COSINE.	COTANG.	TANG.	SINE.

DEG. 54.

35 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	5809397	713732	1·401086	8139466	29
32	5811765	714171	1·400224	8137775	28
33	5814132	714610	1·399363	8136084	27
34	5816498	715050	1·398503	8134393	26
35	5818864	715489	1·397644	8132701	25
36	5821230	715929	1·396785	8131008	24
37	5823595	716369	1·395927	8129314	23
38	5825959	716810	1·395069	8127620	22
39	5828323	717250	1·394213	8125925	21
40	5830687	717691	1·393357	8124229	20
41	5833050	718131	1·392501	8122532	19
42	5835412	718572	1·391647	8120835	18
43	5837774	719014	1·390793	8119137	17
44	5840136	719455	1·389940	8117439	16
45	5842497	719897	1·389087	8115740	15
46	5844857	720338	1·388235	8114040	14
47	5847217	720780	1·387384	8112339	13
48	5849577	721222	1·386534	8110638	12
49	5851936	721665	1·385684	8108936	11
50	5854294	722107	1·384835	8107234	10
51	5856652	722550	1·383988	8105530	9
52	5859010	722993	1·383139	8103826	8
53	5861367	723436	1·382292	8102122	7
54	5863724	723879	1·381445	8100416	6
55	5866080	724322	1·380600	8098710	5
56	5868435	724766	1·379755	8097004	4
57	5870790	725210	1·378910	8095296	3
58	5873145	725654	1·378067	8093588	2
59	5875499	726098	1·377224	8091879	1
60	5877853	726542	1·376381	8090170	0
	COSINE.	COTANG.	TANG.	SINE.	'

DEG. 54.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

36 Deg.

′	SINE.	TANG.	COTANG.	COSINE.
0	.5877853	.726542	1.376351	.8090170
1	.5880206	.726987	1.375540	.8088460
2	.5882558	.727431	1.374699	.8086749
3	.5884910	.727876	1.373859	.8085037
4	.5887262	.728321	1.373019	.8083325
5	.5889613	.728767	1.372180	.8081612
6	.5891964	.729212	1.371342	.8079899
7	.5894314	.729658	1.370504	.8078185
8	.5896663	.730104	1.369667	.8076470
9	.5899012	.730550	1.368831	.8074754
10	.5901361	.730996	1.367995	.8073038
11	.5903709	.731442	1.367161	.8071321
12	.5906057	.731889	1.366326	.8069603
13	.5908404	.732336	1.365493	.8067885
14	.5910750	.732783	1.364660	.8066166
15	.5913096	.733230	1.363827	.8064446
16	.5915442	.733677	1.362996	.8062726
17	.5917787	.734125	1.362165	.8061005
18	.5920132	.734573	1.361335	.8059283
19	.5922476	.735021	1.360505	.8057560
20	.5924819	.735469	1.359676	.8055837
21	.5927163	.735917	1.358848	.8054113
22	.5929505	.736366	1.358020	.8052389
23	.5931847	.736814	1.357193	.8050664
24	.5934189	.737263	1.356367	.8048938
25	.5936530	.737712	1.355541	.8047211
26	.5938871	.738162	1.354716	.8045484
27	.5941211	.738611	1.353891	.8043756
28	.5943550	.739061	1.353068	.8042028
29	.5945889	.739511	1.352244	.8040299
30	.5948228	.739961	1.351422	.8038569
	COSINE.	COTANG.	TANG.	SINE.

Deg. 53.

36 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.5950566	.740411	1.350600	.8036838	29
32	.5952904	.740861	1.349779	.8035107	28
33	.5955241	.741312	1.348958	.8033375	27
34	.5957577	.741763	1.348139	.8031642	26
35	.5959913	.742214	1.347319	.8029909	25
36	.5962249	.742665	1.346501	.8028175	24
37	.5964584	.743117	1.345683	.8026440	23
38	.5966918	.743568	1.344865	.8024705	22
39	.5969252	.744020	1.344049	.8022969	21
40	.5971586	.744472	1.343233	.8021232	20
41	.5973919	.744924	1.342417	.8019495	19
42	.5976251	.745377	1.341602	.8017756	18
43	.5978583	.745829	1.340788	.8016018	17
44	.5980915	.746282	1.339975	.8014278	16
45	.5983246	.746735	1.339162	.8012538	15
46	.5985577	.747188	1.338350	.8010797	14
47	.5987906	.747642	1.337538	.8009056	13
48	.5990236	.748095	1.336727	.8007314	12
49	.5992565	.748549	1.335917	.8005571	11
50	.5994893	.749003	1.335107	.8003827	10
51	.5997221	.749457	1.334298	.8002083	9
52	.5999549	.749911	1.333490	.8000338	8
53	.6001876	.750366	1.332682	.7998593	7
54	.6004202	.750821	1.331875	.7996847	6
55	.6006528	.751276	1.331068	.7995100	5
56	.6008854	.751731	1.330262	.7993352	4
57	.6011179	.752186	1.329457	.7991604	3
58	.6013503	.752642	1.328653	.7989855	2
59	.6015827	.753098	1.327848	.7988105	1
60	.6018150	.753554	1.327044	.7986355	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 53.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

87 Deg.

37 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	.6018150	.753554	1.327044	.7995355	60
1	.6020473	.754010	1.326242	.7994604	59
2	.6022795	.754466	1.325439	.7982253	58
3	.6025117	.754923	1.324638	.7981100	57
4	.6027439	.755379	1.323837	.7979347	56
5	.6029760	.755836	1.323036	.7977394	55
6	.6032080	.756294	1.322237	.7975839	54
7	.6034400	.756751	1.321437	.7974084	53
8	.6036719	.757209	1.320639	.7972329	52
9	.6039038	.757666	1.319841	.7970572	51
10	.6041356	.758124	1.319044	.7968815	50
11	.6043674	.758582	1.318247	.7967058	49
12	.6045991	.759041	1.317451	.7965299	48
13	.6048308	.759499	1.316655	.7963540	47
14	.6050624	.759958	1.315861	.7961780	46
15	.6052940	.760417	1.315066	.7960020	45
16	.6055255	.760876	1.314273	.7958259	44
17	.6057570	.761336	1.313480	.7956497	43
18	.6059884	.761795	1.312687	.7954735	42
19	.6062198	.762255	1.311895	.7952972	41
20	.6064511	.762715	1.311104	.7951208	40
21	.6066824	.763175	1.310314	.7949444	39
22	.6069136	.763636	1.309523	.7947678	38
23	.6071447	.764097	1.308734	.7945913	37
24	.6073758	.764557	1.307945	.7944146	36
25	.6076069	.765018	1.307157	.7942379	35
26	.6078379	.765480	1.306369	.7940611	34
27	.6080689	.765941	1.305582	.7938843	33
28	.6082998	.766403	1.304795	.7937074	32
29	.6085306	.766864	1.304010	.7935304	31
30	.6087614	.767327	1.303225	.7933533	30
'	COSINE.	TANG.	COTANG.	SINE.	'

Deg. 52.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	.6089922	.767789	1.302440	.7931762	29
32	.6092229	.768251	1.301656	.7929990	28
33	.6094535	.768714	1.300873	.7928218	27
34	.6096841	.769177	1.300090	.7926445	26
35	.6099147	.769640	1.299308	.7924671	25
36	.6101452	.770103	1.298526	.7922896	24
37	.6103756	.770567	1.297745	.7921121	23
38	.6106060	.771030	1.296964	.7919345	22
39	.6108363	.771494	1.296185	.7917569	21
40	.6110666	.771958	1.295405	.7915792	20
41	.6112969	.772423	1.294627	.7914014	19
42	.6115270	.772887	1.293848	.7912235	18
43	.6117572	.773352	1.293071	.7910456	17
44	.6119873	.773817	1.292293	.7908676	16
45	.6122173	.774282	1.291517	.7906896	15
46	.6124473	.774748	1.290742	.7905115	14
47	.6126772	.775213	1.289966	.7903333	13
48	.6129071	.775679	1.289192	.7901550	12
49	.6131369	.776145	1.288418	.7899767	11
50	.6133666	.776611	1.287644	.7897983	10
51	.6135964	.777078	1.286871	.7896198	9
52	.6138260	.777544	1.286099	.7894413	8
53	.6140556	.778011	1.285327	.7892627	7
54	.6142852	.778478	1.284556	.7890841	6
55	.6145147	.778946	1.283786	.7889054	5
56	.6147442	.779413	1.283016	.7887266	4
57	.6149736	.779881	1.282246	.7885477	3
58	.6152029	.780349	1.281477	.7883688	2
59	.6154322	.780817	1.280709	.7881898	1
60	.6156615	.781285	1.279941	.7880108	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 52.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

38 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·6156615	·781285	1·279941	·7889108	60
1	·6158907	·781754	1·279174	·7876316	59
2	·6161198	·782222	1·278407	·7876524	58
3	·6163489	·782691	1·277641	·7874732	57
4	·6165780	·783161	1·276876	·7872939	56
5	·6168069	·783630	1·276111	·7871145	55
6	·6170359	·784100	1·275347	·7869350	54
7	·6172648	·784570	1·274583	·7867555	53
8	·6174936	·785040	1·273820	·7865759	52
9	·6177224	·785510	1·273057	·7863963	51
10	·6179511	·785980	1·272295	·7862165	50
11	·6181798	·786451	1·271534	·7860367	49
12	·6184084	·786922	1·270773	·7858569	48
13	·6186370	·787393	1·270013	·7856770	47
14	·6188655	·787864	1·269253	·7854970	46
15	·6190939	·788336	1·268494	·7853169	45
16	·6193224	·788808	1·267735	·7851368	44
17	·6195507	·789280	1·266977	·7849566	43
18	·6197790	·789752	1·266219	·7847764	42
19	·6200073	·790224	1·265462	·7845961	41
20	·6202355	·790697	1·264705	·7844157	40
21	·6204636	·791170	1·263950	·7842352	39
22	·6206917	·791643	1·263195	·7840547	38
23	·6209198	·792116	1·262440	·7838741	37
24	·6211478	·792590	1·261686	·7836935	36
25	·6213757	·793064	1·260932	·7835127	35
26	·6216036	·793537	1·260179	·7833320	34
27	·6218314	·794012	1·259426	·7831511	33
28	·6220592	·794486	1·258674	·7829702	32
29	·6222870	·794961	1·257923	·7827892	31
30	·6225146	·795435	1·257172	·7826082	30
'	COSINE.	SINE.	COTANG.	TANG.	'

Deg. 51.

38 Deg.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·6227423	·795911	1·256421	·7824270	29
32	·6229698	·796386	1·255672	·7822459	28
33	·6231974	·796861	1·254922	·7820646	27
34	·6234248	·797337	1·254174	·7818833	26
35	·6236522	·797813	1·253426	·7817019	25
36	·6238796	·798289	1·252678	·7815205	24
37	·6241069	·798765	1·251931	·7813390	23
38	·6243342	·799242	1·251184	·7811574	22
39	·6245614	·799719	1·250438	·7809757	21
40	·6247885	·800196	1·249693	·7807940	20
41	·6250156	·800673	1·248948	·7806123	19
42	·6252427	·801151	1·248204	·7804304	18
43	·6254696	·801628	1·247460	·7802485	17
44	·6256966	·802106	1·246716	·7800665	16
45	·6259235	·802584	1·245974	·7798845	15
46	·6261503	·803063	1·245232	·7797024	14
47	·6263771	·803541	1·244490	·7795202	13
48	·6266038	·804020	1·243749	·7793380	12
49	·6268305	·804499	1·243008	·7791557	11
50	·6270571	·804978	1·242268	·7789733	10
51	·6272837	·805458	1·241529	·7787909	9
52	·6275102	·805938	1·240790	·7786084	8
53	·6277366	·806418	1·240051	·7784258	7
54	·6279631	·806898	1·239313	·7782431	6
55	·6281894	·807379	1·238576	·7780604	5
56	·6284157	·807859	1·237839	·7778777	4
57	·6286420	·808340	1·237103	·7776949	3
58	·6288682	·808821	1·236367	·7775120	2
59	·6290943	·809302	1·235631	·7773290	1
60	·6293204	·809784	1·234897	·7771460	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 51.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

39 DEG.

′	SINE	TANG	COTANG	COSINE	′
0	·6293204	·809784	1·234897	·7771469	60
1	·6295464	·810265	1·234162	·7769629	59
2	·6297724	·810747	1·233429	·7767797	58
3	·6299983	·811230	1·232696	·7765965	57
4	·6302242	·811712	1·231963	·7764132	56
5	·6304500	·812195	1·231231	·7762298	55
6	·6306758	·812678	1·230499	·7760464	54
7	·6309015	·813161	1·229768	·7758629	53
8	·6311272	·813644	1·229038	·7756794	52
9	·6313528	·814128	1·228308	·7754957	51
10	·6315784	·814611	1·227578	·7753121	50
11	·6318039	·815095	1·226849	·7751283	49
12	·6320293	·815580	1·226121	·7749445	48
13	·6322547	·816064	1·225393	·7747606	47
14	·6324800	·816549	1·224665	·7745767	46
15	·6327053	·817034	1·223938	·7743926	45
16	·6329306	·817519	1·223212	·7742086	44
17	·6331557	·818004	1·222486	·7740244	43
18	·6333809	·818490	1·221761	·7738402	42
19	·6336059	·818976	1·221036	·7736559	41
20	·6338310	·819462	1·220312	·7734716	40
21	·6340559	·819948	1·219588	·7732872	39
22	·6342808	·820435	1·218865	·7731027	38
23	·6345057	·820922	1·218142	·7729182	37
24	·6347305	·821409	1·217419	·7727336	36
25	·6349553	·821896	1·216698	·7725489	35
26	·6351800	·822384	1·215976	·7723642	34
27	·6354046	·822871	1·215256	·7721794	33
28	·6356292	·823359	1·214535	·7719945	32
29	·6358537	·823847	1·213816	·7718096	31
30	·6360782	·824336	1·213097	·7716246	30
	COSINE.	TANG.	COTANG.	SINE.	′

Deg. 50.

39 DEG.

′	SINE	TANG	COTANG	COSINE	′
31	·6363526	·824825	1·212378	·7714395	29
32	·6365270	·825314	1·211660	·7712544	28
33	·6367513	·825803	1·210942	·7710692	27
34	·6369756	·826292	1·210225	·7708840	26
35	·6371998	·826782	1·209508	·7706986	25
36	·6374240	·827271	1·208792	·7705132	24
37	·6376481	·827762	1·208076	·7703278	23
38	·6378721	·828252	1·207361	·7701423	22
39	·6380961	·828742	1·206646	·7699567	21
40	·6383201	·829233	1·205932	·7697710	20
41	·6385440	·829724	1·205219	·7695853	19
42	·6387678	·830216	1·204505	·7693996	18
43	·6389916	·830707	1·203793	·7692137	17
44	·6392153	·831199	1·203081	·7690278	16
45	·6394390	·831691	1·202369	·7688418	15
46	·6396626	·832183	1·201658	·7686558	14
47	·6398862	·832675	1·200947	·7684697	13
48	·6401097	·833168	1·200237	·7682835	12
49	·6403332	·833661	1·199527	·7680973	11
50	·6405566	·834154	1·198818	·7679110	10
51	·6407799	·834648	1·198109	·7677246	9
52	·6410032	·835141	1·197401	·7675382	8
53	·6412264	·835635	1·196693	·7673517	7
54	·6414496	·836129	1·195986	·7671652	6
55	·6416728	·836624	1·195279	·7669785	5
56	·6418958	·837118	1·194573	·7667918	4
57	·6421189	·837613	1·193867	·7666051	3
58	·6423418	·838108	1·193162	·7664183	2
59	·6425647	·838604	1·192457	·7662314	1
60	·6427876	·839099	1·191753	·7660444	0
	COSINE.	TANG.	COTANG.	SINE.	′

Deg. 50.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

40 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
0	·6427576	·839099	1·191753	·7660444	60
1	·6430104	·838505	1·191049	·7658574	59
2	·6432632	·840091	1·190346	·7656704	58
3	·6434539	·840587	1·189643	·7654832	57
4	·6436785	·841084	1·188941	·7652960	56
5	·6439011	·841581	1·188239	·7651087	55
6	·6441236	·842078	1·187538	·7649214	54
7	·6443461	·842575	1·186837	·7647340	53
8	·6445685	·843073	1·186136	·7645465	52
9	·6447909	·843570	1·185437	·7643590	51
10	·6450132	·844068	1·184737	·7641714	50
11	·6452355	·844567	1·184038	·7639838	49
12	·6454577	·845065	1·183340	·7637960	48
13	·6456798	·845564	1·182642	·7636082	47
14	·6459019	·846063	1·181944	·7634204	46
15	·6461240	·846562	1·181247	·7632325	45
16	·6463460	·847062	1·180551	·7630445	44
17	·6465679	·847561	1·179855	·7628564	43
18	·6467898	·848061	1·179159	·7626683	42
19	·6470116	·848561	1·178464	·7624802	41
20	·6472334	·849062	1·177769	·7622919	40
21	·6474551	·849563	1·177075	·7621036	39
22	·6476767	·850064	1·176382	·7619152	38
23	·6478984	·850565	1·175688	·7617268	37
24	·6481199	·851066	1·174996	·7615383	36
25	·6483414	·851568	1·174303	·7613497	35
26	·6485628	·852070	1·173612	·7611611	34
27	·6487842	·852572	1·172920	·7609724	33
28	·6490056	·853075	1·172229	·7607837	32
29	·6492268	·853577	1·171539	·7605949	31
30	·6494480	·854080	1·170849	·7604000	30
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 49.

40 DEG.

'	SINE.	TANG.	COTANG.	COSINE.	'
31	·6496692	·854533	1·170160	·7602170	29
32	·6498903	·855067	1·169471	·7600290	28
33	·6501114	·855601	1·168782	·7598389	27
34	·6503324	·856095	1·168094	·7596498	26
35	·6505533	·856599	1·167407	·7594606	25
36	·6507742	·857103	1·166720	·7592713	24
37	·6509951	·857608	1·166033	·7590820	23
38	·6512158	·858113	1·165347	·7588926	22
39	·6514366	·858618	1·164661	·7587031	21
40	·6516572	·859124	1·163976	·7585136	20
41	·6518778	·859629	1·163291	·7583240	19
42	·6520984	·860135	1·162607	·7581343	18
43	·6523189	·860641	1·161923	·7579446	17
44	·6525394	·861148	1·161240	·7577548	16
45	·6527598	·861655	1·160557	·7575650	15
46	·6529801	·862162	1·159874	·7573751	14
47	·6532004	·862669	1·159192	·7571851	13
48	·6534206	·863176	1·158511	·7569950	12
49	·6536408	·863684	1·157830	·7568050	11
50	·6538609	·864192	1·157149	·7566148	10
51	·6540810	·864700	1·156469	·7564246	9
52	·6543010	·865209	1·155789	·7562343	8
53	·6545209	·865718	1·155110	·7560439	7
54	·6547408	·866227	1·154431	·7558535	6
55	·6549607	·866736	1·153753	·7556630	5
56	·6551804	·867246	1·153075	·7554724	4
57	·6554001	·867755	1·152397	·7552818	3
58	·6556198	·868265	1·151721	·7550911	2
59	·6558395	·868776	1·151044	·7549004	1
60	·6560590	·869286	1·150368	·7547096	0
'	COSINE.	COTANG.	TANG.	SINE.	'

Deg. 49.

NATURAL SINES AND TANGENTS TO A RADIUS 1.

41 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
0	.6560590	.869286	1.150368	.7547096	60
1	.6562785	.869797	1.149692	.7545187	59
2	.6564980	.870308	1.149017	.7543278	58
3	.6567174	.870820	1.148342	.7541368	57
4	.6569367	.871331	1.147668	.7539457	56
5	.6571560	.871843	1.146994	.7537546	55
6	.6573752	.872355	1.146321	.7535634	54
7	.6575944	.872868	1.145648	.7533721	53
8	.6578135	.873380	1.144976	.7531808	52
9	.6580326	.873893	1.144304	.7529894	51
10	.6582516	.874406	1.143632	.7527980	50
11	.6584706	.874920	1.142961	.7526065	49
12	.6586895	.875433	1.142290	.7524149	48
13	.6589083	.875947	1.141620	.7522233	47
14	.6591271	.876462	1.140950	.7520316	46
15	.6593458	.876976	1.140281	.7518398	45
16	.6595645	.877491	1.139612	.7516480	44
17	.6597831	.878006	1.138944	.7514561	43
18	.6600017	.878521	1.138276	.7512641	42
19	.6602202	.879037	1.137608	.7510721	41
20	.6604386	.879552	1.136941	.7508800	40
21	.6606570	.880068	1.136274	.7506879	39
22	.6608754	.880585	1.135608	.7504957	38
23	.6610936	.881101	1.134942	.7503034	37
24	.6613119	.881618	1.134277	.7501111	36
25	.6615300	.882135	1.133612	.7499187	35
26	.6617482	.882653	1.132947	.7497262	34
27	.6619662	.883170	1.132283	.7495337	33
28	.6621842	.883688	1.131620	.7493411	32
29	.6624022	.884206	1.130957	.7491484	31
30	.6626200	.884725	1.130294	.7489557	30
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 48.

41 Deg.

′	SINE.	TANG.	COTANG.	COSINE.	′
31	.6628379	.885244	1.129632	.7487629	29
32	.6630557	.885763	1.128970	.7485701	28
33	.6632734	.886282	1.128308	.7483772	27
34	.6634910	.886801	1.127647	.7481842	26
35	.6637087	.887321	1.126987	.7479912	25
36	.6639262	.887841	1.126327	.7477981	24
37	.6641437	.888361	1.125667	.7476049	23
38	.6643612	.888882	1.125008	.7474117	22
39	.6645785	.889403	1.124349	.7472184	21
40	.6647959	.889924	1.123690	.7470251	20
41	.6650131	.890445	1.123032	.7468317	19
42	.6652304	.890967	1.122375	.7466382	18
43	.6654475	.891489	1.121718	.7464446	17
44	.6656646	.892011	1.121061	.7462510	16
45	.6658817	.892534	1.120405	.7460574	15
46	.6660987	.893057	1.119749	.7458636	14
47	.6663156	.893579	1.119094	.7456699	13
48	.6665325	.894103	1.118439	.7454760	12
49	.6667493	.894626	1.117784	.7452821	11
50	.6669661	.895150	1.117130	.7450881	10
51	.6671828	.895674	1.116476	.7448941	9
52	.6673994	.896199	1.115823	.7446999	8
53	.6676160	.896723	1.115170	.7445058	7
54	.6678326	.897248	1.114518	.7443115	6
55	.6680490	.897773	1.113866	.7441173	5
56	.6682655	.898299	1.113214	.7439229	4
57	.6684818	.898825	1.112563	.7437285	3
58	.6686981	.899351	1.111912	.7435340	2
59	.6689144	.899877	1.111262	.7433394	1
60	.6691306	.900404	1.110612	.7431448	0
′	COSINE.	COTANG.	TANG.	SINE.	′

Deg. 48.